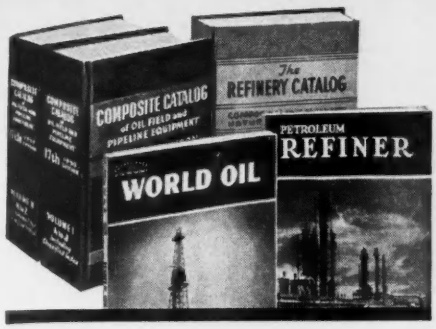

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for the drilling-producing-pipe line industry

PETROLEUM REFINER and The REFINERY CATALOG
for the refining-natural gasoline industry

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Looking Ahead

UNDER HIS SUPERVISION, Petroleum Administration for Defense will be no larger than necessary, stated Bruce K. Brown, after being sworn in November 22 as Deputy Petroleum Administrator. At present, he said, probably no more than 40 industry men will be asked to serve with PAD. Most of them will become regular employees of government, although President Truman issued order under which Brown and other industry officials can and will serve in key mobilization posts without government pay. Brown was Assistant Deputy Petroleum Administrator for War in World War II and more recently chairman of Military Petroleum Advisory Board. A major problem facing PAD, said Brown, is procurement of necessary steel and other materials for oil and gas industry operations.

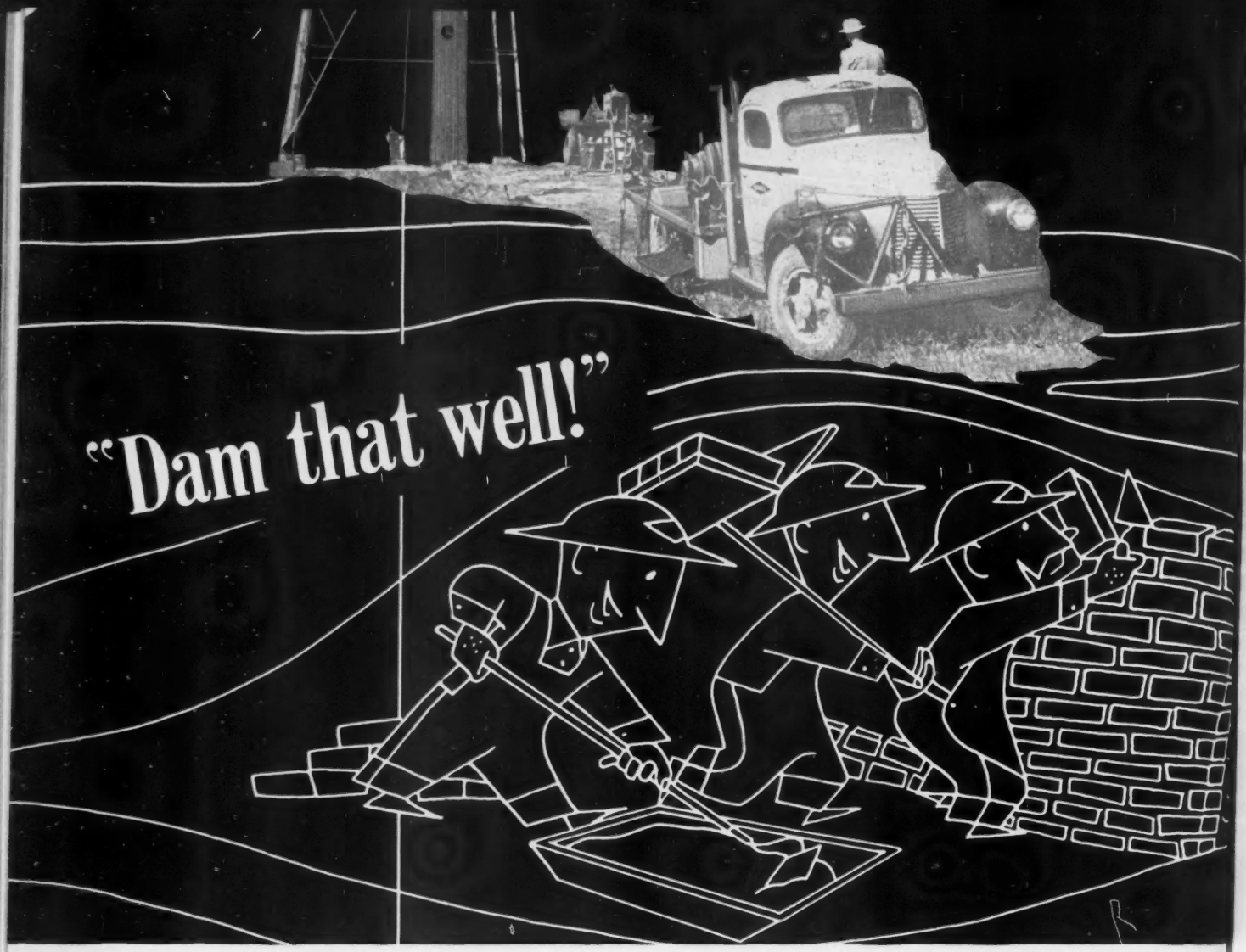
UP-TO-DATE ANALYSIS of the scarcity of oil field tubular goods will be made by a special committee at annual meeting of Interstate Oil Compact Commission at Houston December 11-13. A. W. Thompson, president, American Association of Oilwell Drilling Contractors, will present paper on subject.

SHORTAGES OF OTHER METALS as well as steel may soon plague oil industry. The 35 percent cut in civilian use of aluminum, effective January 1, is only the beginning of restrictions that soon will spread throughout the field of scarce materials. Metals probably next in line for cuts include cobalt, zinc, tungsten, cadmium, and manganese. Among non-metals, there have been cuts in rubber and building materials. In curtailments, government is making special efforts to hurt small concerns as little as possible.

THE SHORT, "LAME-DUCK" session of Congress is generally expected to accomplish very little. Consideration of an excess profits tax on corporations will be principal issue, but tax matters always move slowly and with much debate in Congress. Republicans naturally want to hold up legislation until new session in January, which will make effective important Republican gains in recent election.

GENERAL UPWARD PRESSURE ON PRICES affects oils as well as most other products, and markups in oil products or even crude eventually may become necessary. Oil companies already have higher costs for many materials as well as labor, following recent general boost of 6 percent in wages and salaries. Now the big item, steel, may go higher. Benjamin F. Fairless, president of U. S. Steel Corporation, told API at Los Angeles that fifth round of wage increases is already well under way, and said that in event of a similar wage increase in steel industry, steel prices would have to rise with increasing costs, in order to preserve financial soundness of steel companies and allow them to proceed with scheduled vast expansion of steelmaking facilities.

WITH MORE THAN 4 MILLION acres under lease, the Western and Northwestern Oklahoma district is due for a big wildcat play next year. This area is Oklahoma's untested "oil frontier," and the acreage is held in large blocks, with good geology. Counties where most activity is expected include Alfalfa, Beaver, Dewey, Ellis, Garfield, Grant, Major and Wood. Leaseholders are supporting each other in major deals, and major oil companies are giving help to independents.



DOWELL PLASTIC SERVICE has been used successfully in the reconditioning of hundreds of wells

Control of water and gas encroachment poses a vital problem in many old wells. On a recent job, Dowell Electric Pilot Surveys revealed areas of gas and water encroachment that were choking off production on a well. The well was then plugged back 20 feet with plastic, and plastic was squeezed around the casing shoe. Result? *Before* remedial work, oil production was 12 bbls. per day with 90% water and a gas-oil ratio of 20,000 cu. ft. per bbl. *After Dowell Service,* oil production was 50 bbls. per day with only 30% water and a gas-oil ratio of 3700 cu. ft. per bbl.

Dowell Plastics have proved themselves ideal for many workover and recompletion jobs. If necessary, the Dowell Electric Pilot is used to determine the well's permeability profile and the sources of fluid entrance. Then, the Dowell engineer uses a specially engineered bailer to spot the plastic in the right place. The plastic enters the well as a fluid . . . then becomes an impervious solid at a predetermined time. Dowell plastics provide excellent bonding and penetrating qualities that form a permanent dam against encroaching fluids.

Ask your local Dowell station for complete information on the many uses of Dowell Plastic Service in well workover and completion programs.

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Ask your nearest Dowell station for complete information on these Dowell services and products: Acidizing Service, Electric Pilot Services, Plastic Service, Chemical Scale Removal Service for heat exchange equipment, Jelflake, Paraffin Solvents, Magnesium Anodes for Corrosion Control and Bulk Inhibited Hydrochloric Acid.

"Petroleum Promotes Progress"

Look to DOWELL

FOR OIL INDUSTRY CHEMICAL SERVIC

Editor's Page

PUBLIC RELATIONS PROGRAM PAYS

MANY TIMES in the past year oil men have expressed the desire to know if the industry's public relations program was proving successful. The answer to this question was given at the recent annual meeting of the American Petroleum Institute, when Opinion Research Corporation reported on a survey made recently of public attitude toward oil. Fortunately, it is possible to compare this study with a similar survey made a year ago.

Some of the highlights revealed by these two studies:

That 72 percent of the American people now have a generally favorable impression of the oil industry, a gain of 4 percent over 1949.

That only 12 percent of the American people now think there should be more government regulation of the oil industry, a decrease of 5 percent since 1949.

That 43 percent of the American people now feel there is a great deal of competition among the companies who manufacture and sell gasoline and oil, a gain of 7 percent over 1949.

These gains mean more when translated into number of people. A 4 percent gain means 3½ million adults; a 5 percent increase is equal to 4¼ million adults; and a 7 percent growth means nearly 6 million.

THUS IT BECOMES apparent that many more people have a friendly attitude toward oil today than a year ago. There should be another large growth in friendly attitude toward the industry during the coming year. API directors voted a sizeable increase in the public relations budget, much of which will be spent in a more intensive advertising campaign, and the momentum of past efforts also should be felt to a greater extent during the coming year.

The industry needs these new friends and all its old ones. There are many problems ahead, just to mention a few that will be before the new session of Congress:

All business corporations face the prospect of excess profit taxes, and some particular businesses may be singled out for special treatment.

The industry's 27½ percent depletion allowance very likely is to be questioned again.

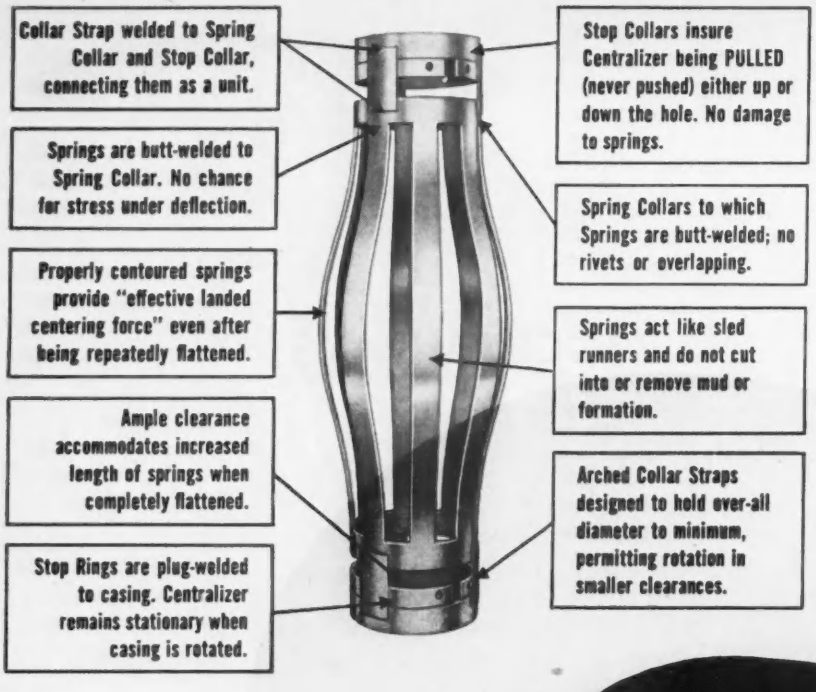
A Senate investigating committee now is studying the national fuel policy with the aim of controlling the "end use" of coal, oil, gas and electricity.

Truman's veto creates a greater need for amending the Natural Gas Act to free independent gas producers from Federal Power Regulation than ever before.

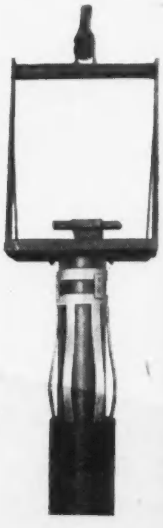
THERE IS STILL A LONG WAY to go, despite improved public feeling toward oil. In the battles ahead—and they are battles—every person engaged in the oil industry should prepare to defend his business against the ceaseless barrage of government operation and bureaucracy. The industry's public relations program is doing a good job, but cannot be expected to do all the work. Only if everyone takes it upon himself to tell his friends and neighbors about his work and problems can there be a full understanding of the industry. To do this, many oil men need to become better versed in the industry's problems and contributions to the American people. Nothing confronting the industry today is of greater importance.

As Abraham Lincoln said: "Public sentiment is everything. With public sentiment, nothing can fail. Without it, nothing can succeed. Consequently, he who molds public sentiment goes deeper than he who enacts statutes or pronounces decisions. He makes statutes and decisions possible or impossible to be executed."

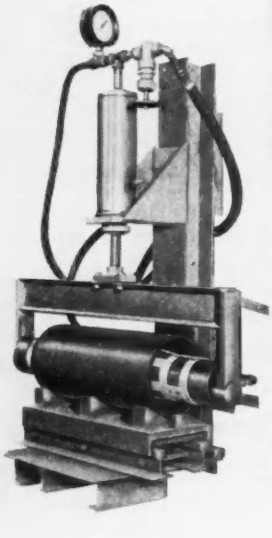
Warren L. Baker


Collar Strap welded to Spring Collar and Stop Collar, connecting them as a unit.
Springs are butt-welded to Spring Collar. No chance for stress under deflection.
Properly contoured springs provide "effective landed centering force" even after being repeatedly flattened.
Ample clearance accommodates increased length of springs when completely flattened.
Stop Rings are plug-welded to casing. Centralizer remains stationary when casing is rotated.
Stop Collars insure Centralizer being PULLED (never pushed) either up or down the hole. No damage to springs.
Spring Collars to which Springs are butt-welded; no rivets or overlapping.
Springs act like sled runners and do not cut into or remove mud or formation.
Arched Collar Straps designed to hold over-all diameter to minimum, permitting rotation in smaller clearances.

EASY STARTING WITHOUT "SNUBBING"

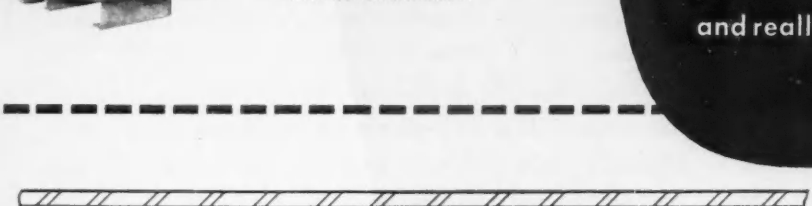


Testing to determine the maximum number of springs, of optimum bowed height and length, to insure easy starting, particularly of the first few joints when there is no accumulated weight. Minimum interval spacing of Baker Model "G" Casing Centralizers also was determined with this testing equipment.

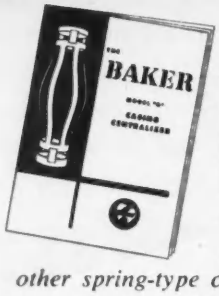


With this testing device it is possible not only to simulate rugged downhole travel by repeatedly flattening the springs, but also to find the effective centering force of the centralizer in the open hole, after such treatment. The maximum centering force is easily determined from a performance curve showing the centering force at various intervals of deflection.

Operators who know ALL the facts about the Baker Model "G" Casing Centralizer specify and run them exclusively. They know from experience that they are buying the greatest possible centering force for their casing, to be applied *exactly where they want it in the hole.* Isn't that what you too expect and really want from a casing centralizer?



Here is the ideal in spring design and mounting, found only in the Baker Model "G" Casing Centralizer. Note how the load point is imposed directly upon the casing; and how the properly "contoured" spring is free to move along the smooth surface of the casing as it deflects under compression. There is no chance for concentration of stress to cause a permanent set, or to result in breaking of the spring. Note that ample clearance exists between Stop Rings and Spring Collars to accommodate the increased length of the springs which results from their complete flattening.



Additional interesting facts and illustrations are contained in a new 16-page brochure which proves conclusively that no other spring-type centralizer even approaches the EFFECTIVE LANDED CENTERING FORCE afforded by the Baker Model "G" Casing Centralizer. Ask for your copy today from any Baker office or representative.

BAKER OIL TOOLS, INC.
Houston • LOS ANGELES • New York

The Changing Panorama

Oil Earnings Plow-Back Subject for Publicity

AMONG THE INDUSTRY'S public relations efforts, which now deserve and get more attention than ever before, one that is especially significant and commendable is the periodic survey of the vast capital expenditures or investments that the industry is making in improving and expanding its facilities. Handled through the American Petroleum Institute, these surveys have shown that the petroleum industry has been investing more than $2 billion per year since the war in improving facilities and expanding capacity to provide oils for America.

While these surveys have been given wide publicity when made, the industry possibly has not been fully exploiting the possibilities of gaining good will through disseminating information on its investment projects and pointing out their value to the public. Especially should there be a constant effort by the industry to link up its capital investments with its earnings, or profits, showing that by virtue of the earnings it has been able to achieve, the industry has found it possible to improve and expand facilities, providing ample oil products of high quality at reasonable price. The industry regularly "plows back" a high percentage of its earnings into the business, improving and expanding facilities in all departments, because demand for petroleum constantly is increasing.

Most oil companies now issue not only annual statements but also quarterly statements. In each of these, figures are given on the company's net income or profit for the period involved, and the report may contain discussion of the company's and the industry's operations and outlook. In connection with these figures on earnings, it would be desirable for the industry and enlightening to the public to show how these earnings are beneficial not to a few wealthy stockholders but to thousands of stockholders who are working men and women, widows, universities, or institutions; that the earnings are beneficial most of all to the oil consuming public, providing the means to buy the properties, drill the wells, and build the plants to keep oils always available for purchase at reasonable price.

In general, the public sees, and is led to see, not much more than a dollar mark and a figure that may look plenty big in the case of a large oil company. The newspaper story says that for the first nine months of 1950, Company X reported a net profit of $10 million, or $30 million, or nearly $100 million. The reader says that is a lot of money and the rich are getting richer, and though gasoline isn't high, maybe it ought to be cheaper. His reaction might be turned to a better advantage for the company and the industry if he knew that the earnings were a relatively small return on hundreds of millions of dollars invested by thousands of small stockholders, and that the earnings were being used in large measure to drill new wells and build new pipe lines and refineries and tankers to make sure he could continue to get plenty of gasoline, heating oil, and other petroleum products when needed and at reasonable price.

Without these earnings, the oil companies would not have the funds to keep facilities in line with growing oil use and could not raise the funds because investors will not put cash into businesses without reasonable earning power.

Oil Men's Influence on Defense Plans Needed

THE PETROLEUM INDUSTRY is concerned primarily with its own problems and responsibilities in the defense program, such as solving the military aviation gasoline shortage, dealing with the steel shortage, and fitting company operations into the picture of prospective demands on the industry.

However, men of the industry also share in the broader, general responsibility of doing all in their power to assure sanity, efficiency, and success of the defense or mobilization program as a whole. It has been often pointed out that a modern major war is ultimately a deadly industrial war, a war eventually won by superiority in production. This being true, the nation's interests require maximum utilization of the brains of industry and effective influence of business men upon policies and actions to be pursued by the nation in regard to defense efforts.

Oil men, as well as other businessmen, are duty-bound to insist that the defense program be carried out in sound, efficient, business-like manner, with minimum of waste, injustices, disruptions, and hardships. This is especially necessary in view of the repeated warnings that mobilization will go on for years, with each year bringing staggering costs.

Since the tremendous defense program is only beginning and the means of financing it has not yet been determined, businessmen generally are seriously concerned with this fundamental problem of how the heavy defense costs will be paid. More than ever before, because of these prospective heavy defense costs, the American people face a critical threat of ruinous, economically fatal inflation. Such a development is definitetly threatened unless the government demonstrates the courage to pay the great costs in the sound but hard way of raising them as we go out of the national income, through increased taxes for all Americans, sharp curtailment of non-defense spending, and real government economy.

The only other way in which the heavy costs can be raised is through deficit financing. In this method the government would in effect merely print up new billions of dollars of new money that would immediately or ultimately compete with existing dollars in purchase of goods, further diluting the value of the dollar which already has declined to about 56 percent of prewar value. The resultant inflation could be temporarily postponed to some extent but only by total controls and restrictions, and as soon as those were lifted, the true reduced worth of the dollar would be clearly established.

More wisely, we could and should pay the costs as we go, in high taxes, tight credit, and government economy. This method has been urged by several prominent businessmen's associations and by economic research institutions. It would balance government expenditures with income, keep costs in hand, provide stability, and promote the national security.

For the oil man it is just as important for his government to follow a sound course as for his industry and his company to do so. And the oil man has not only the right but the duty to insist on wise government policy for this critical period.

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Supply-Demand in Favorable Balance

By RAY L. DUDLEY, Publisher, and WARREN L. BAKER, Editor

IT IS NOW ASSURED that the industry will start the new year in a strong economic position. Supply and demand should be in favorable relationship, despite the uncertainties created by the heavy dependence of consumption volumes upon the weather during this season of the year because heating oil constitutes such a large proportion of the requirements during winter months. Following cutbacks in October and November, production rates are to be further reduced in December as a result of the 160,000-barrel per day slash in Texas' permissive output. This action promises that stocks of crude and refined products will not be excessive at the beginning of 1951. On the other hand, barring unseasonably cold weather in December, stocks will be adequate. Thus, the industry apparently is due to start the new year in a sounder position than it entered 1950. In contrast with the present favorable prospects, inventories a year ago were burdensome.

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THE LONGER RANGE viewpoint also is encouraging. Under present conditions where stocks of both crude and products are to be in good balance with requirements by the end of the year, the industry is afforded an excellent opportunity to maintain its currently favorable economic position. Changes in crude stocks can be used as a barometer of the need to decrease or increase producing rates, and trends in refined product inventories will indicate whether refiners need to enlarge or reduce the output of different products.

By observing stock trends and quickly changing operations to fit existing conditions, the industry can continue to maintain a healthy position unless there are very sharp and drastic changes in consuming volumes as a result of military needs or the influence of weather on heating oil demand.

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SOME REDUCTION and improvement in crude stocks now is likely to occur during the remainder of the year as a result of lower producing rates fixed for December. This will be in contrast with additions made in September and October, when about 7 million barrels were added to crude inventories to boost them to nearly 245 million barrels and cause apprehension that too much oil might go to storage.

The possibility of crude stocks becoming burdensome has been eliminated by November trends and prospective trends in December. It is now indicated that year-end crude stocks are likely to approximate 240 million barrels, or some 12 to 13 million barrels less than at the beginning of 1949.

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REFINED PRODUCT STOCKS also are in a favorable position, accumulations having slowed down sonsiderably in recent weeks. Distillate and residual fuel oil inventories are below year ago levels, and gasoline stocks for the nation as a whole are at the same level as a year ago for the first time since last July. In view of enlarged demand for all products, these stock positions put the refined product market in a much better position than a year ago when both heating oil and gasoline inventories were at all-time peaks.

The most important thing is for the industry to guard against excessive gasoline stocks in the area east of California, where inventories are 5 million barrels greater than 1949 levels. Accumulation of too much gasoline in this region during the low winter consuming season can be prevented by proper adjustment of refinery yields to reduce gasoline output and increase heating oil production. If this is done, there is nothing on the horizon at this time to indicate anything but a good supply-demand relationship for the industry.

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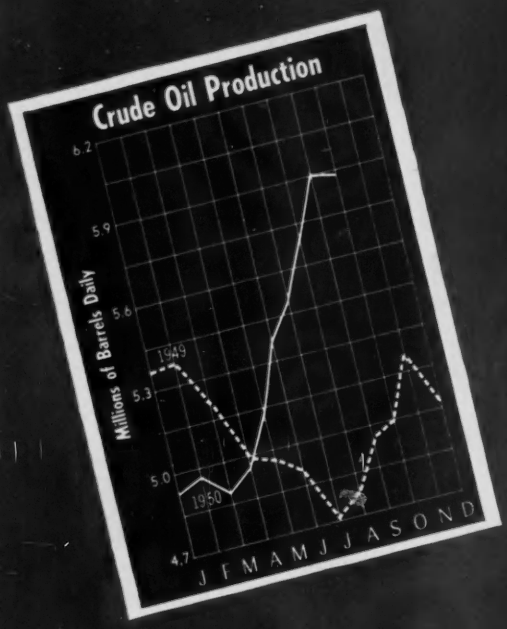
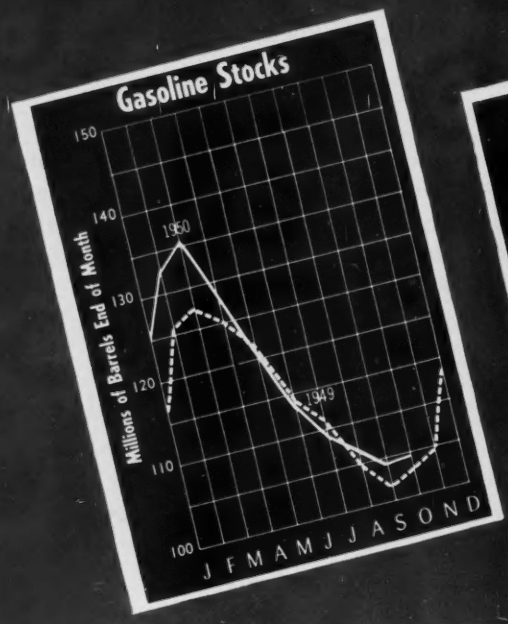
A VERY NOTABLE IMPROVEMENT has occurred in the California situation. During the closing months of 1949, the West Coast industry was in a very poor condition as excessive producing rates had forced the accumulation of large quantities of both crude and refined products. Heavy demand due to the Korean war has boosted demand for West Coast oil sharply in recent months. As a result, California's residual fuel stocks have been reduced nearly 12 million barrels in a year and today total but 16 million barrels; and gasoline stocks are only 14 million barrels or 3 million barrels below year ago levels.

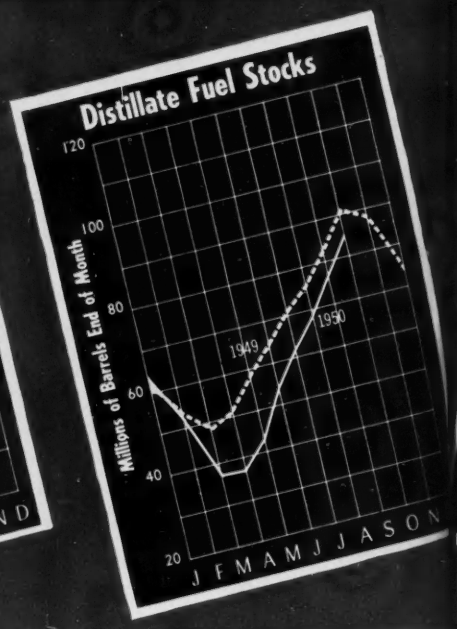
The strong position of the industry in California was demonstrated at the end of October when prices for heavy crudes were advanced for the third time this year.

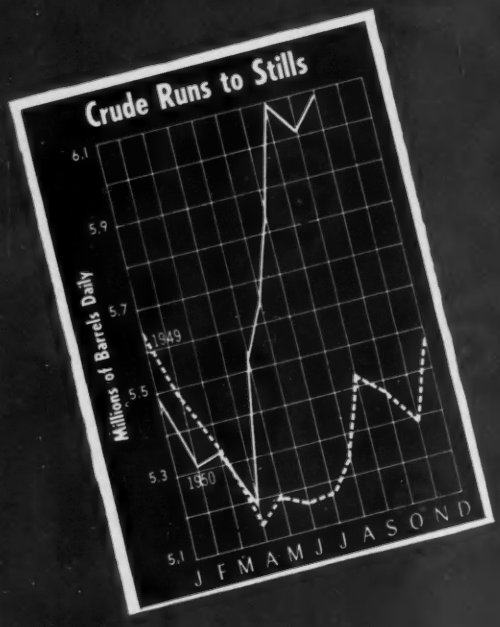
Petroleum

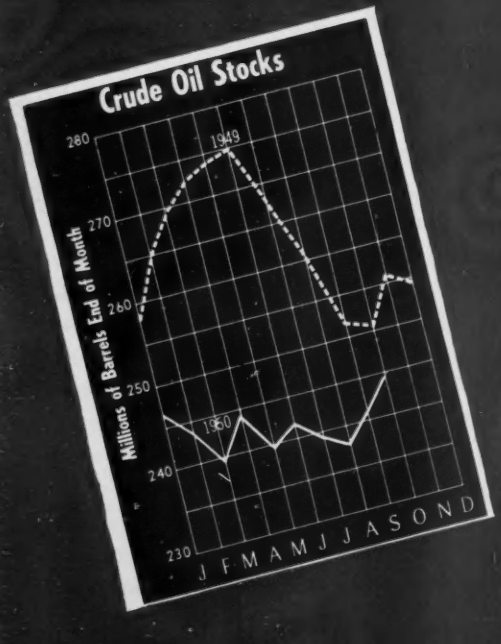
By CECIL W. SMITH
Statistical Editor









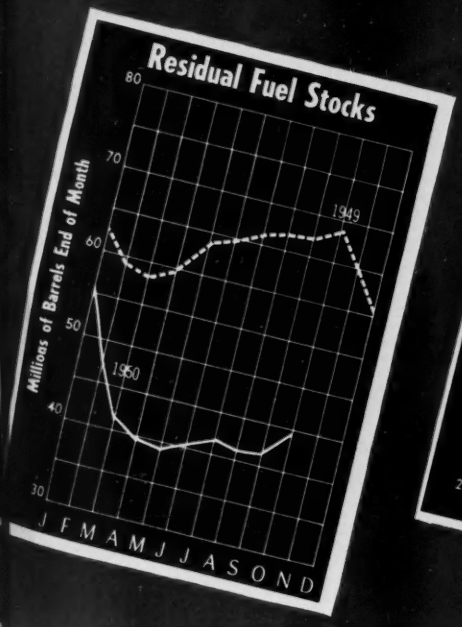


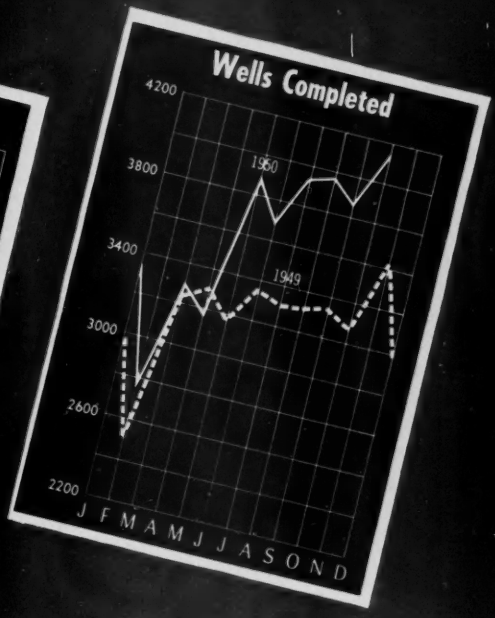
State Crude Oil Production

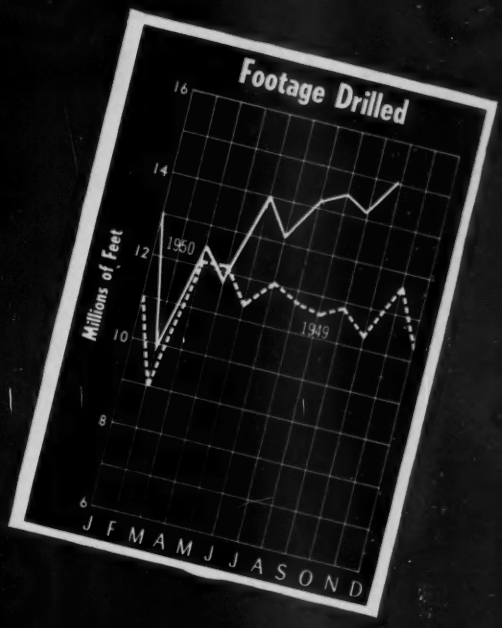
(THOUSANDS OF BARRELS)

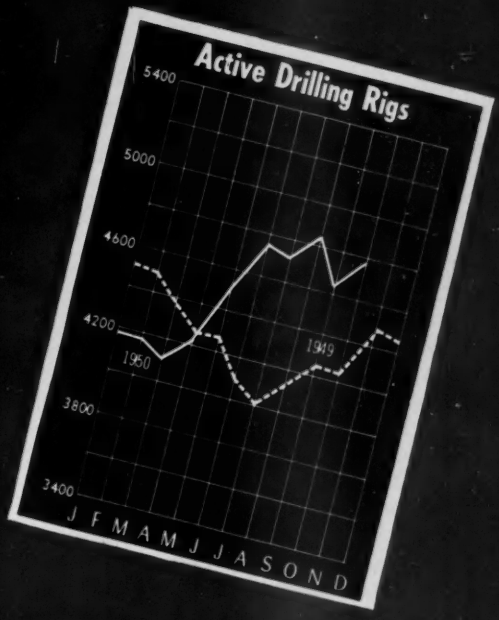
STATE or DISTRICT	DAILY AVERAGE PRODUCTION				TOTAL FIRST TEN MONTHS		
	October, 1950	Sept., 1950	October, 1949	% Diff. October, '49-'50	1950	1949	% Diff. '49-'50
Alabama	2.3	2.2	1.2	+ 91.7	569	370	+ 53.8
Arkansas	86.5	86.0	78.8	+ 9.8	26,104	24,746	+ 5.5
California	943.2	917.8	876.9	+ 7.6	268,850	279,769	— 3.9
Colorado	70.4	64.9	66.7	+ 5.5	18,805	20,168	— 6.8
Florida	1.5	1.6	1.0	+ 50.0	391	381	+ 2.6
Illinois	179.2	179.5	177.1	+ 1.2	52,351	53,670	— 2.5
Indiana	30.9	30.9	29.7	+ 4.0	8,465	7,772	+ 8.9
Kansas	304.3	301.9	277.1	+ 9.8	89,033	84,548	+ 5.3
Kentucky	29.0	27.9	25.9	+ 12.0	8,297	7,087	+ 17.1
Louisiana	604.4	601.0	538.3	+ 12.3	172,191	157,075	+ 9.6
North Louisiana	126.2	125.4	120.8	+ 4.5	37,331	36,940	+ 1.1
South Louisiana	478.2	475.6	417.5	+ 14.5	134,860	120,135	+ 12.3
Michigan	42.2	44.3	45.4	— 7.0	13,414	13,659	— 1.8
Mississippi	111.0	110.7	99.0	+ 12.1	31,893	31,899	— 0.1
Missouri	0.1	0.1	0.1	.....	25	40	— 37.5
Montana	22.3	23.3	23.9	— 6.7	6,721	7,719	— 12.9
Nebraska	4.1	3.2	1.6	+156.3	911	239	+281.2
New Mexico	130.3	135.1	131.1	— 0.6	39,616	39,923	— 0.8
New York	14.1	14.6	11.2	+ 25.9	3,650	3,567	+ 2.3
Ohio	9.6	9.4	9.3	+ 3.2	2,862	2,872	— 0.3
Oklahoma	483.3	466.4	418.7	+ 15.4	133,725	125,678	+ 6.4
Pennsylvania	32.4	31.5	30.3	+ 6.9	9,764	9,574	+ 2.0
Tennessee	0.1	0.1	0.1	.....	19	15	+ 26.7
Texas	2,607.1	2,669.1	2,019.6	+ 29.1	677,801	615,952	+ 10.0
Dist. 1—South Central	31.1	30.8	27.5	+ 13.1	8,556	8,065	+ 6.1
Dist. 2—Middle Gulf	152.7	153.0	128.6	+ 18.7	40,005	39,861	+ 0.4
Dist. 3—Upper Gulf	470.2	472.5	405.8	+ 15.9	124,042	120,733	+ 2.7
Dist. 4—L. Gulf-S.W.	236.5	237.6	198.2	+ 19.3	62,960	59,952	+ 5.0
Dist. 5—East Central	43.1	44.2	35.7	+ 20.7	10,656	11,374	— 6.3
Dist. 6—Northeast	401.5	411.3	344.3	+ 16.6	108,632	106,589	+ 1.9
Dist. 7-B—N. Central	78.4	75.1	63.1	+ 24.2	20,846	18,351	+ 13.6
Dist. 7-C—West Central	77.4	72.4	51.8	+ 49.4	18,407	13,936	+ 32.1
Dist. 8—West	872.0	924.3	584.3	+ 49.2	215,189	173,311	+ 24.2
Dist. 9—North	154.2	156.5	139.5	+ 10.5	43,639	40,723	+ 7.2
Dist. 10—Panhandle	90.0	91.4	92.1	— 2.3	27,664	27,622	+ 0.2
Utah	3.4	3.3	2.5	+ 36.0	978	301	+224.9
Virginia	0.1	0.1	0.1	.....	21	36	— 41.7
West Virginia	8.0	7.7	8.4	— 4.8	2,381	2,350	+ 1.3
Wyoming	164.3	168.5	123.0	+ 33.6	48,914	38,858	+ 25.9
Total United States	5,884.1	5,901.1	4,997.0	+ 17.8	1,617,751	1,528,268	+ 5.9

Trends in the U.S.









Crude Oil and Refined Products Trends

(THOUSANDS OF BARRELS)

MONTH	CRUDE OIL			GASOLINE		DISTILLATE FUEL		RESIDUAL FUEL	
	Production Daily	Runs to Stills Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month
1948:									
August	5,577	5,621	231,954	2,532	95,445	1,038	65,887	1,248	55,009
September	5,435	5,376	237,302	2,416	90,518	961	73,854	1,154	58,682
October	5,632	5,594	243,972	2,490	92,426	1,069	79,992	1,268	61,456
November	5,675	5,672	250,066	2,551	95,589	1,081	80,658	1,277	64,865
December	5,688	5,720	256,254	2,626	103,697	1,106	71,475	1,299	64,021
1949:									
January	5,365	5,641	258,648	2,538	116,621	1,063	61,584	1,348	62,508
February	5,376	5,480	265,216	2,484	126,054	1,004	53,937	1,282	59,398
March	5,224	5,352	269,341	2,470	127,443	993	48,923	1,258	58,190
April	5,012	5,141	272,520	2,494	125,351	846	51,231	1,147	59,668
May	4,972	5,195	273,912	2,585	121,602	813	57,442	1,138	63,576
June	4,903	5,162	274,691	2,597	114,041	771	64,730	1,041	64,628
July	4,704	5,173	267,586	2,613	111,217	835	71,553	1,040	66,084
August	4,780	5,241	260,585	2,593	104,879	902	76,037	1,078	66,843
September	4,940	5,427	251,689	2,617	101,799	1,002	83,213	1,110	67,117
October	5,997	5,373	250,932	2,643	103,287	1,001	90,643	1,141	68,673
November	5,210	5,293	256,010	2,594	104,707	962	88,212	1,180	65,112
December	5,024	5,475	253,356	2,633	111,521	1,032	75,207	1,203	60,193
1950:									
January	4,922	5,483	246,610	2,575	125,298	1,048	63,932	1,209	55,808
February	4,967	5,316	243,750	2,552	132,796	1,026	52,206	1,172	47,828
March	4,878	5,336	241,098	2,539	133,766	938	37,777	1,154	41,860
April	4,968	5,193	244,605	2,508	128,057	977	37,530	1,048	39,979
May	5,143	5,535	239,877	2,647	121,035	997	42,739	1,063	39,482
June	5,378	5,655	242,287	2,748	114,074	1,037	53,679	1,069	40,124
July	5,484	5,882	240,270	2,835	111,055	1,040	62,555	1,140	42,165
August	5,665	6,067	237,393	2,932	107,067	1,089	68,426	1,148	40,979
September	5,901	6,004	241,631	2,811	104,383	1,157	76,734	1,181	42,330
October	5,884	6,089	244,860	2,844	104,757	1,213	85,269	1,205	44,472
Oct. 1950 Change:									
In Month	−17	+85	+3,229	+33	+374	+56	+8,535	+24	+2,142
In Year	−113	+716	−6,072	+201	+1,470	+212	−5,374	+64	−24,201
Week Ended:									
Nov. 11, 1950	5,911	6,018	242,239	2,781	105,465	1,209	86,721	1,234	45,140
Nov. 12, 1949	5,185	5,127	254,311	2,527	103,577	978	92,117	1,116	68,527

Monthly News Analysis

Chapman Says PAD Seeks Adequate Steel for Oil

Secretary of Interior Oscar L. Chapman, at the annual meeting of the American Petroleum Institute in Los Angeles, November 13, bluntly criticized the steel industry as having inadequate productive capacity and called on it for expansion of facilities, in analyzing defense problems of the petroleum industry. At the same time he commended the oil industry for having been aggressive in postwar expansion and for having given effective cooperation to the government in meeting current defense problems.

As head of the Petroleum Administration for Defense, Chapman indicated that a growing scarcity of steel is the most serious problem confronting the petroleum industry, and declared that more steel-making capacity is necessary to prevent slowing the whole industrial machine as well as oil industry efforts.

"It is extremely disturbing to note the growing shortage in the supply of materials, equipment, and facilities reqiured by the oil and gas industries," Chapman stated. "That shortage appears to be reaching alarming proportions so far as the supply of specialized steel products is concerned.

"The Petroleum Administration for Defense is acting to meet that problem," he continued. "In consultation with experts from the oil and gas industries, we are preparing data now to support our requests for adequate supplies of steel and other critical materials needed by these industries. We will do our best to obtain these supplies. Unless they are forthcoming, the government may be forced to regulate the use of steel or other critical materials in oil and gas operations. Such regulations may be the only way to attempt equitably to distribute materials in short supply and direct their use in the interests of the defense program.

"But allocations and rules to administer materials which are in short supply are not enough. We have learned in oil and gas that the safest and best way to meet expanding demands is to increase supply, not ration a deficiency. This belief in the virtue of expanding production has always been a characteristic of the oil industry. Traditionally, oil men fear they will not have enough. As a result, they do not hesitate to enlarge their productive capacity. Steel men, on the other hand, have too often seemed to fear that they would have too much."

If allocations of steel or other products are required they will be employed, said the PAD administrator, but a fight must be waged for greater productive capacity. "The simple fact is that inadequate capacity to make steel puts the brakes on our whole industrial machine and threatens both the National Defense Program and the civilian economy. It is time that the steel makers faced economic realities and raised their sights."

The defense program for oil and gas means, above all, said Chapman, that all the oil and gas required for the armed forces and essential industrial and civilian use must be made available at the times and in the places needed. Emphasis is being placed on highly skilled and able personnel rather than a large organization in staffing PAD, he stated, and the industry is cooperating by furnishing experts. Special efforts are being made to avoid unnecessary regulation and controls and to preserve competition as a proved, dependable incentive for whatever action and accomplishment is essential for the national defense.

One of the first urgent problems dealt with by PAD was the shortage in supply of military aviation gasoline. But Chapman reported encouraging progress in solving the problem, which he said had been reduced to "manageable proportions," though still far from being completely solved. "A small group of industry technical experts, assembled under leadership of PAD, has known what to do, when to do it, and where there were units within the industry who could do what had to be done. We have not needed formal directives. Nor have we attempted merely to ration a shortage. Instead, by welding technical skill with economic incentives, a substantial increase in the production of these fuels has already been achieved."

If orders or directives are necessary, promised Chapman, they will be evolved carefully, cooperatively, and with particular regard to the interests of the public and the many large and small businesses that make up the industry.

"Believing in competition as we do," said the PAD chief, "we should be slow to regulate, slow to allocate. Under a competitive system, economic incentives are often quicker and far more effective." A striking example of this, he said, was the successful handling of the military aviation gasoline shortage, when PAD chose not to allocate the shortage but to try to make allocation unnecessary by providing incentives to produce more.

Whenever any order or directive proves to be necessary, said Chapman, both industry and government should immediately search for ways and means to make it possible to wipe that order off the books. And the same principle should apply to the whole Petroleum Administration for Defense. "We should constantly strive to work ourselves out of a job, so that normal competitive forces can continue in the future as they have in the past to provide us with whatever petroleum products are desired."

As the basic reason for the productive vigor of the oil industry, competition should be restrained or disturbed as little as possible, declared the Petroleum Administrator. He will endeavor, therefore, he said, to leave at the end of this emergency the same competitive relationships among the units of the oil and gas industry as exist today.

Chapman pledged that in requesting or directing cooperative action by the oil industry in the defense program, he would do all in his power to make sure no one could successfully claim the action violates the anti-trust laws. "However," he added, "I am sure you do not expect any blanket endorsement of actions, past, present, or future, not directly related to specific conduct formally requested in the interest of the defense program."

Porter Asks Understanding By Public and Government

Supplying products vitally essential to national defense and the nation's economy, the petroleum industry faces serious problems in these critical times, and a sympathetic understanding of its problems by the public and the government is of foremost importance, declared Frank M. Porter, president of The API, in his address at the annual meeting November 15. The industry can fulfill its responsibilities, he explained, only if it can

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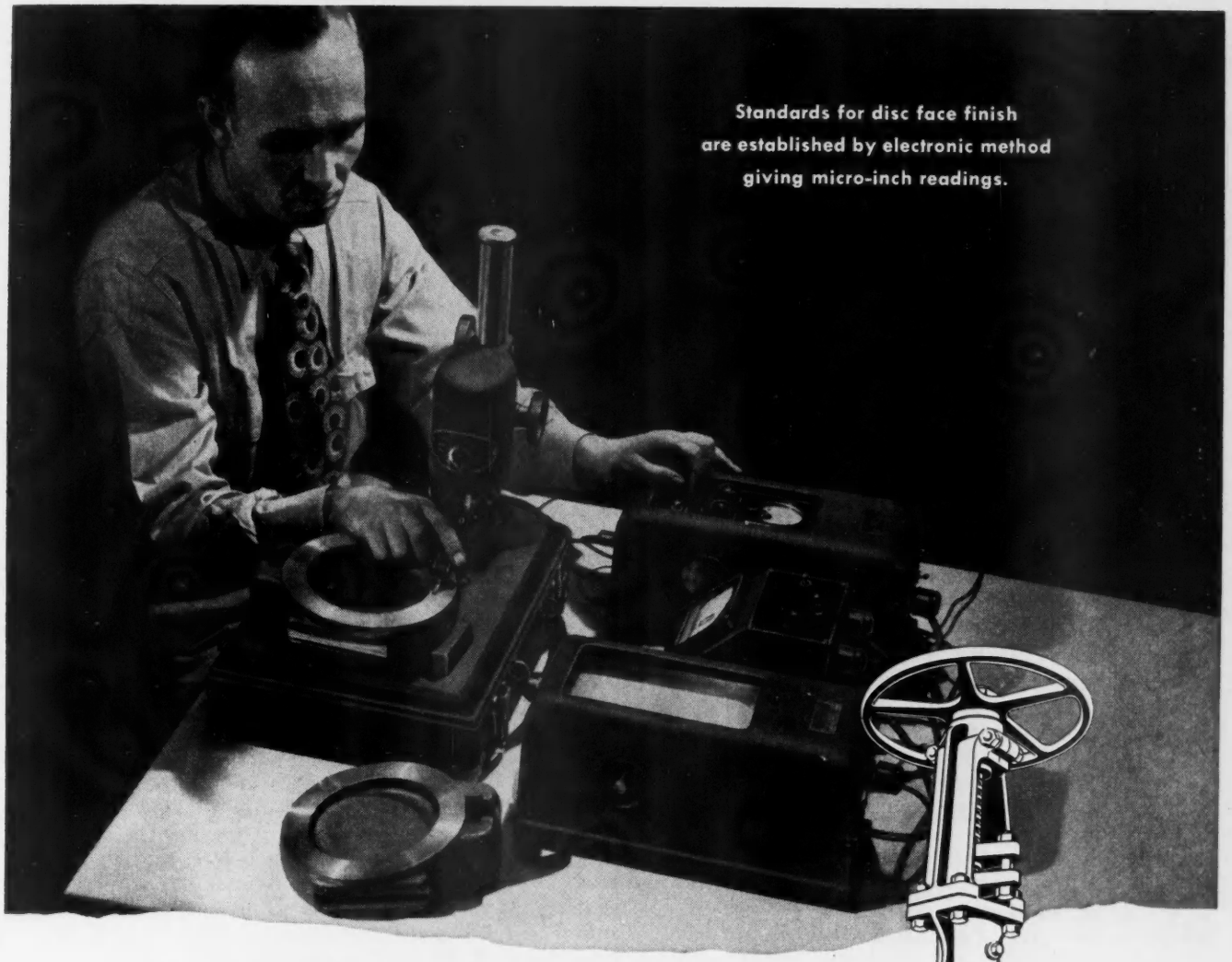

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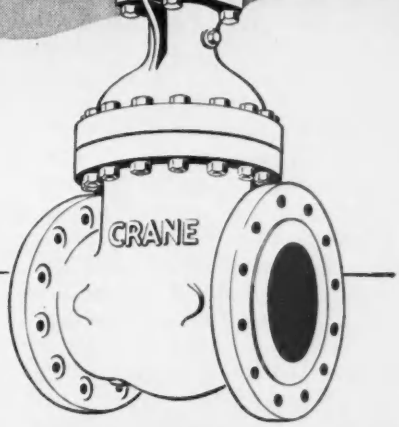

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continue to operate on a free, competitive basis, with private initiative encouraged, in an atmosphere of sympathetic understanding on the part of government and the public.

Toward gaining this understanding by public and government, the industry is putting forth effective efforts through individual action and the public relations program of the API, said Porter, but even greater efforts are needed.

"The industry has spent, and is now spending, substantial sums for public relations and advertising," he said, "yet no institutional advertising will produce completely satisfactory results until the industry membership sees fit to take on the job of public education more seriously than we have done heretofore.

"A more effective use of management-employe relations, individual company advertising, and the public and private contacts of oil men everywhere will prove effective avenues of approach," Porter suggested.

A master objective for the various educational programs is needed for effectiveness, he stated, and in his opinion, the most important theme to be stressed by all is the proved ability of the industry, under the competitive system, to supply the consumer with adequate quantities of high-quality products, when and where needed, at lowest cost.

"When the public consciousness is aroused to this truth," Porter asserted, "the industrial liberties and freedoms of the oil industry will be safe from attacks of those who would nationalize the business and industrial enterprise of this nation."

Petroleum will be one of the most important factors in final determination of whether governments of free people will survive or whether the totalitarian philosophy of communism will prevail, Porter said, in emphasizing importance of sympathetic public and government understanding of the industry's problems.

"These considerations have a most sobering effect upon those charged with the heavy responsibilities of serving a segment of our economy so vital to the ultimate outcome of the global conflict in which we may find ourselves involved.

"If the petroleum industry is to fulfill its responsibilities in repelling the growing threats to our national security; if we are to meet the requirements of an expanding domestic economy and a rising standard of living, it is essential that conditions must prevail which will assure the industry a reasonable opportunity to continue finding adequate supplies of petroleum for such purposes, in accordance with their paramount necessity.

"These conditions can exist only in an atmosphere of sympathetic understanding on the part of government and the public," he continued.

"I want to emphasize, said Porter, "that the problems are real and menacing and that they can be solved only by an awareness on the part of those in industry and a determination to give freely of time and effort in defending a business which is conducting itself and its operations in the public interest."

Legislation Would Restrict Oil Industry's Freedom

The oil industry now constantly faces serious threats of adverse legislation, some of which would disrupt or destroy the industry by killing free competition, free enterprise, and private initiative, declared Jake L. Hamon, independent oil producer of Dallas and president of Mid-Continent Oil and Gas Association, at the annual meeting of the API in Los Angeles November 15. In view of these threats, he urged a constant study of proposed legislation and a continuance of efforts at all levels of industry action to prevent an end to the free enterprise, competitive style of American business.

Freedom of independent gas and oil producers from Federal Power Commission or other bureaucratic control still is one of the most important issues that must be resolved, asserted Hamon, in view of the veto of the Harris-Kerr amendment of the Natural Gas Act, which would have assured such freedom.

"Since we have none of the benefits inherent in public utility status," he asserted, "we see no reason for being regulated as public utilities." Producers of natural gas feel, he said, that they have the same right of freedom from federal regulation that is enjoyed by the producers of every other commodity used in America today. At present, he said, "we are in even greater need of an amendment to the Natural Gas Act to free the independent producers of natural gas from FPC regulation than we were before the Harris-Kerr bill was passed." He was referring to FPC's action after the veto, rescinding an earlier order that had promised independents continued exemption from FPC regulation.

The threat of FPC regulation of gas producers is seriously retarding development and marketing of natural gas, Hamon indicated. "Today there are trillions of cubic feet of gas in the Southwest which can be produced by independent producers for consumers all over the U. S. who want the gas," he said, "if the producers are freed from FPC regulation and domination."

Freedom to produce and sell gas in a competitive market will stimulate sale and use of gas, promote gas conservation, greatly benefit citizens and local governments of producing areas, and give consumers all over the nation a choice in fuel for both domestic and industrial use, Hamon declared.

Although he is an independent producer, Hamon decried attacks against integrated oil companies and efforts to divorce the different divisions of the companies. Those concerns have evolved, he indicated, through free competition, and it is free competition that gives small operators the opportunity to succeed and grow, promotes efficiency, and assures consumers low costs of petroleum products.

In the interests of the nation, the tidelands question needs to be promptly cleared up, said Hamon. "But it probably won't be," he added, "without a lot of malicious unfounded attacks on the industry by the same group of radicals, gossip columnists, and their fellow travelers who have besieged us before."

Other critical problems touched upon by Hamon were the attacks on state conservation laws, attacks on the depletion allowance, and other changes in tax laws. In conclusion, he reminded oil men that these were only a few of the major problems facing the industry and that new ones are arising daily.

FPC Threat Discourages Sale of Oil, Gas Lands

The threat of Federal Power Commission regulation of gas and oil production already is preventing consummation of deals for sale of properties and may continue to do so. This was asserted by George Wagner of Arthur Andersen and Company, New York, an accounting firm, in discussing accounting problems of the oil and gas industries November 14 at the annual meeting of the API.

One of the reasons why prospective purchasers may decide against buying a gas producing property is an important accounting problem that is involved, Wagner explained. The property may be a good one, with proved valuable reserves, and yet not be attractive to the prospective buyer because it would not be profitable

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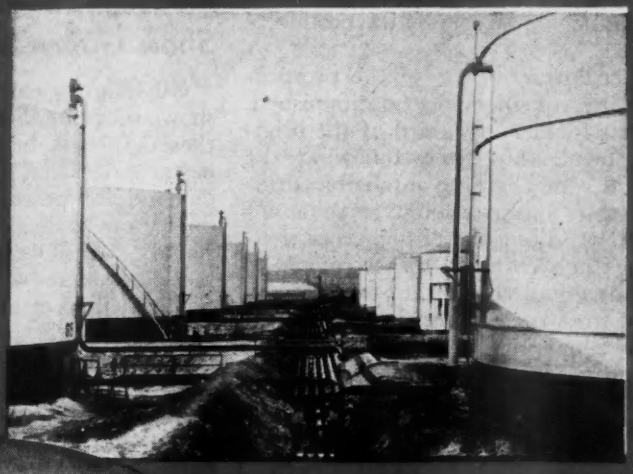

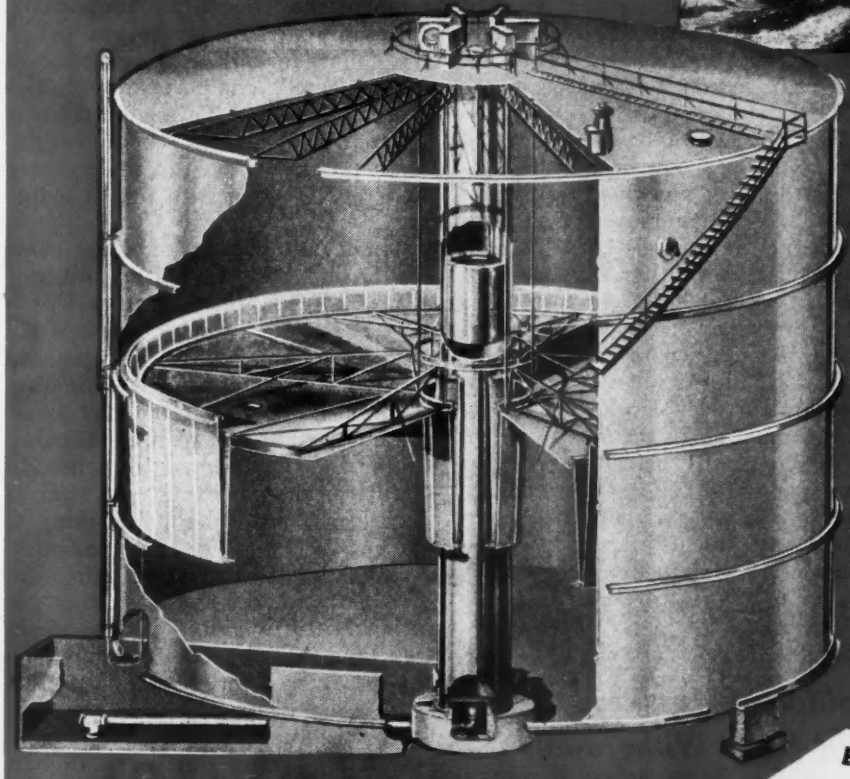

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under FPC fixing of prices at which the gas could be sold by the producer-owner.

The attractiveness of the prospective investment might be diminished, it was further explained, if the original owner has been following the practice of charging intangible drilling costs off as drilling expense instead of taking the option of capitalizing such costs. If these costs have been capitalized and are to be recovered from reserves for depletion, then they represent a part of the capital investment and will be considered by FPC in limiting rate of return on investment and prices that can be charged for gas by the producer, in event FPC initiates such regulation under the Natural Gas Act.

If a producer has been expensing these drilling costs, then FPC will not permit him, under regulation, to include them in his capital investment, judging by previous rulings of the commission, the accounting expert stated.

Another problem raised by the threat of FPC regulation of all gas production is the possible necessity of setting up allocation of costs as between oil and gas production.

Jones, Porter Re-elected To Chief Offices in API

The two top posts in leadership of API will be filled in 1951 by the same men who served in 1950, and three other officers also have been re-elected, while three vice presidents for the coming year will be new in those positions.

W. Alton Jones, Cities Service Company, New York, has been re-elected chairman of the API board, and Frank M. Porter, New York, was reelected as president of the Institute at the annual meeting in Los Angeles November 15.

The three new vice presidents are J. C. Donnell, II, The Ohio Oil Company, Findlay, Ohio, vice president for production; W. L. Stewart, Jr., Union Oil Company of California, Los Angeles, vice president for refining; and Harry J. Kennedy, Continental Oil Company, Houston, vice president for marketing.

T. E. Swigart, Shell Pipe Line Corporation, Houston, was re-elected vice president for transportation. B. B. Jennings, Socony-Vacuum Oil Company, Inc., New York, was re-elected treasurer of API. Lacey Walker, New York, was re-elected secretary and assistant treasurer.

The meeting will be returned to Chicago in 1951.

Industry Earnings for 1950 Show Gain Over Last Year

Oil industry earnings for 1950 will show substantial improvement over those of 1949, because of somewhat better prices and definitely stronger demand for petroleum products. Industry operations have shown exceptional expansion this year in order to meet an increase of more than 10 percent in petroleum demand. In contrast, crude production, refinery runs, and product prices trended downward throughout 1949, when demand just about equaled that of the preceding year. Oil company earnings have reflected directly these changes in trends, quarterly earnings in 1950 having compared progressively more favorably with those of 1949 as this year has unfolded.

For the first nine months of this year, 38 oil companies reported aggregate net income of $1,160,898,554, an increase of 18 percent over the total of $983,896,430 reported by those companies in the corresponding period of 1949, according to a report by Carl H. Pforzheimer & Company, stock brokers, New York. Earnings of these companies in the third quarter of 1950 were 61 percent above the same period of 1949, as compared with a year-to-year gain of 17 percent in the second quarter and a decrease of 16 percent in the first quarter, the report stated.

California Ups Production And Halts Withdrawals

Although bearing an important part of the load in supplying oils for U. S. fighting in Korea, the California oil industry has materially stepped up production and stopped the withdrawals from storage that were necessary during the summer.

During October there was a net increase in stocks, averaging about 20,000 barrels per day, as additions of gasoline and fuel oil to storage exceeded withdrawals of crude and miscellaneous products.

California's crude production in October averaged about 943,000 barrels daily. That was 73,000 barrels a day more than the output of 870,000 barrels daily recorded in June.

During the past summer, there were steady withdrawals from stocks of both crude and products in meeting the heavy demand. Those withdrawals ranged from 50,000 to 200,000 barrels daily for all oils combined.

Reports of the Oil Producers Agency of California showed that total demand exceeded total supply by approximately 50,000 barrels daily in June, 100,000 daily in July, 185,000 daily in August, and 85,000 daily in September. The deficiencies of supply, met by drawing on storage, involved especially crude oil, residual fuel oil, and light fuel oils.

Government May Reject Gas Administration for Defense

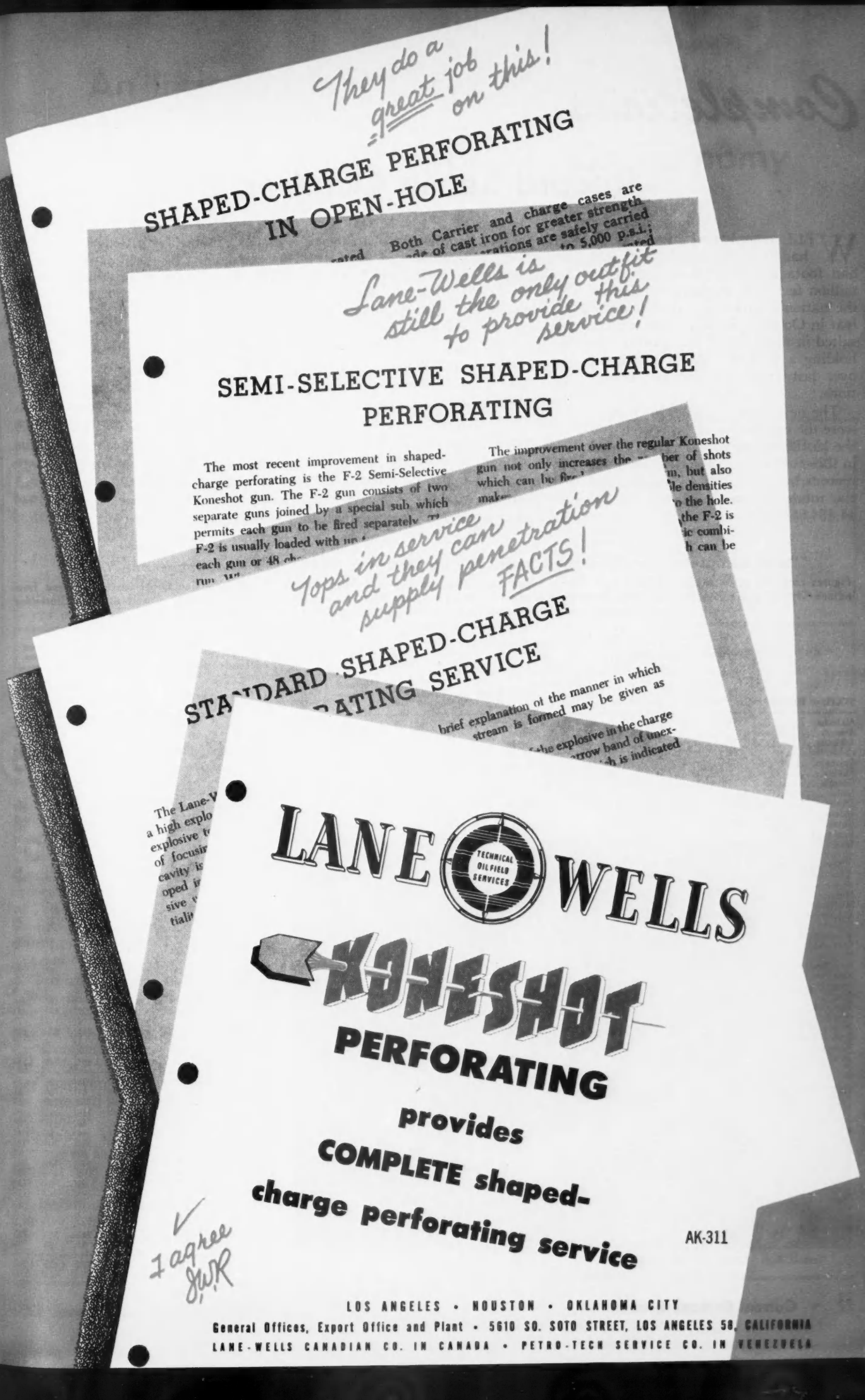
It has been indicated that the government may reject the proposal of a group representing the gas industry, calling for a "Gas Administration for Defense," comparable with but separate from the Petroleum Administration for Defense. The present defense program puts the gas industry under PAD along with the oil industry.

Hugh A. Stewart, when he was acting Deputy Petroleum Administrator expressed disapproval of the proposed separate agency because of the "close interrelationship of gas and oil." He suggested a compromise plan, recommending appointment of an assistant Deputy Petroleum Administrator for Gas, chosen from the gas industry, and an expert gas staff to handle gas problems, all working as part of PAD, with efforts coordinated with those dealing with petroleum. Stewart said he saw no insuperable obstacles to providing the gas industry the kind of representation it requires and deserves. He also suggested that upon annual appointment of the National Petroleum Council the latter part of this year, provision should be made for appointment of a Gas Panel as a part thereof.

Stewart added that, in fact, efforts were made to expand gas industry representation on the present NPC, but extreme difficulty was encountered in finding sufficient gas industry men willing to serve.

Stewart's preference for joint handling of gas and oil matters under PAD is known to be shared by some men prominent in the gas industry. Likewise, it doubtless is shared by many companies and operators that produce both gas and oil, for the reason that it would be simpler and easier to deal with only one government agency rather than two.

Gas matters were satisfactorily handled by the Petroleum Administration for War, and though the gas industry has expanded greatly since the war, it probably can be safely assumed that gas problems similarly could be satisfactorily dealt with by PAW's present counterpart, PAD.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Completions

Record Set in October

WELL completions in the U. S. had never totaled 4100 nor had footage drilled amounted to 15 million feet in a single month before the nation's drillers accomplished the feat in October. Such activity has resulted in this year's drilling campaign holding a lead of almost 14 percent over last year's ten months' operations.

The new marks reached in October were the completion of 4198 wells and the 15,186,145 feet of hole represented in those wells. Previously, the monthly records had been held by August and the totals had been 4033 wells and 14,484,669 feet.

In the first ten months of this year, wells completed amounted to 36,591, which was an increase of 13.8 percent over the 32,143 finaled by the end of October, 1949. An even greater margin was held by this year's footage drilled. To date, total penetration amounted to 132,420,443 feet and that was 16.1 percent greater than the 114,104,474 feet recorded in last year's comparable months.

A slightly smaller percent of the wells drilled in search of production this year have proved successful in comparison with the past several years. This is explained to some extent by the fact that a slightly higher percent of the drilling has been exploratory, a type of development in which failures occur in about four out of five ventures.

This year 65.1 percent of all new wells drilled for oil, distillate, or gas found production. A year ago the rate was 65.9 percent and in 1948, the previous record-drilling year, it was 68.1 percent. The reason is that 19.6 percent of all wells drilled so far this year were hazardous exploratory tests, while the same class amounted to 19.5 and 18.0 percent respectively in 1949 and 1948.

Well Completions in the United States During October, 1950, and Cumulative for Year

(Figures compiled by WORLD OIL Staff from private reports and other sources as follows: Illinois from Illinois Geological Survey; Indiana from Indiana Division of Geology; Missouri from Missouri Geological Survey; Tennessee from Tennessee Division of Geology; Bradford, Kane-Clarendon and Allegany fields of Pennsylvania and New York from the *"Producers Monthly."*)

STATE or DISTRICT	MONTHLY COMPLETIONS, OCTOBER, 1950									TOTAL COMPLETIONS				CUMULATIVE TOTALS January-October					Rigs in Operation (Drilling, Rigging-Up and Shut Down)		
	NEW WELLS								Total Drilled Deeper												
	Oil	Dist.	Gas	Dry	Water Input	Gas Input	Water Disposal	Total New		Oct., 1950	Sept., 1950	Oct., 1949	Footage October, 1950	Wells 1950	Wells 1949	Percent Diff.	Footage 1950	Footage 1949	Oct. 31, 1950	Sept. 30, 1950	Oct. 31, 1949
Alabama	3			3				6		6	1	2	33,719	37	14	+164.3	157,464	68,674	5	7	3
Arizona				1				1		1		1	5,766	5	5		21,363	15,603	4	5	4
Arkansas	17			8				25		25	31	32	73,795	320	274	+ 16.8	1,061,189	1,114,112	36	26	27
California	86		10	32				128	8	136	159	178	554,728	1,543	2,123	- 27.3	6,252,286	8,473,558	232	208	254
Colorado	2		2	8				12		12	13	7	57,140	67	57	+ 17.5	265,878	247,112	18	21	22
Florida											1	3		11	16	- 31.3	69,518	108,707	1	1	4
Georgia														3	4	- 25.0	13,270	12,437			1
Idaho				1				1		1			5,597	4			14,137		1	2	
Illinois	120		1	162				283		283	309	294	673,152	2,405	2,180	+ 10.3	5,243,114	5,224,729	255	255	225
Indiana	44		1	99				144		144	146	125	260,789	1,344	1,030	+ 30.5	2,324,885	1,895,115	190	198	135
Kansas	203		64	174			4	445		445	345	276	1,426,480	3,302	2,503	+ 31.9	10,611,688	8,275,723	330	322	310
Kentucky	51		19	49				119		119	149	93	231,209	1,040	774	+ 34.4	1,923,027	1,426,530	108	106	98
Louisiana	115	11	25	73				224	2	226	218	180	1,374,760	2,064	1,883	+ 9.6	12,452,129	10,175,312	229	227	229
North Louisiana	58	1	18	40				117	2	119	113	110	416,292	1,096	1,129	- 2.9	3,832,382	3,636,907	76	67	86
South Louisiana	57	10	7	33				107		107	105	70	958,468	968	754	+ 28.4	8,619,747	6,538,405	153	160	143
Maryland				2				2		2	1	1	10,155	4	1	+300.0	16,636	4,900		2	
Michigan	31		9	50				90		90	75	71	236,524	700	770	- 9.1	1,666,322	1,746,264	138	142	142
Mississippi	10	2	1	13				26		26	23	39	184,891	284	293	- 3.1	2,041,950	2,149,032	28	28	32
Missouri				3				3		3		7	5,915	26	22	+ 18.2	20,500	11,119	6	8	7
Montana	17		2	11				30		30	24	30	67,308	227	224	+ 1.3	566,371	552,599	41	41	36
Nebraska	6		2	8				16		16	16	4	66,906	90	11	+718.2	379,357	46,616	13	11	3
Nevada																			1	2	
New Mexico	31		13	14				58	2	60	50	44	268,926	521	436	+ 19.5	2,316,813	1,899,661	87	87	96
New York	26				18			44		44	88	51	62,758	644	759	- 15.2	945,598	1,087,160	100	112	80
North Dakota												1			3	-100.0		14,808	2	1	2
Ohio	30		32	41				103	1	104	99	90	207,759	839	870	- 3.6	1,731,062	1,857,995	161	156	154
Oklahoma	309	1	17	193	7		4	531	17	548	522	362	1,974,021	4,536	3,586	+ 26.5	16,026,452	12,742,209	692	671	523
Oregon																			1	1	
Pennsylvania	54		34	10	50	8		156	1	157	143	145	300,788	1,374	1,682	- 18.3	2,508,921	3,027,860	255	253	229
South Dakota											2	1		5	6	- 16.7	16,922	12,803	1	1	2
Tennessee														3	27	- 88.9	3,993	27,001	8	8	7
Texas	945	16	98	501	2	1	1	1,564	40	1,604	1,411	1,165	6,662,998	14,123	11,647	+ 21.3	59,818,572	48,141,914	1,481	1,369	1,295
Dist. 1 S. Central	23			26				49	2	51	42	37	151,030	417	462	- 9.7	1,176,623	1,410,745	38	30	35
Dist. 2 Middle Gulf	41	4	5	36				86	1	87	48	46	479,563	586	545	+ 7.5	3,372,184	3,187,109	61	55	51
Dist. 3 Upper Gulf	69	3	5	45		1		123		123	144	112	750,716	1,319	1,124	+ 17.3	7,796,838	6,749,125	150	126	115
Dist. 4 L. Gulf-S.W.	78	6	10	42				136	2	138	131	91	673,824	1,380	1,117	+ 23.5	6,653,903	5,550,759	118	121	95
Dist. 5 E. Central	5			12				17		17	12	13	96,814	165	168	- 1.8	740,170	788,584	19	18	29
Dist. 6 Northeast	69	2	3	15				89	1	90	42	62	411,049	557	752	- 25.9	2,681,819	3,308,040	44	33	48
Dist. 7-B N. Central	108		6	85			1	200	1	201	201	144	493,621	1,704	1,586	+ 7.4	4,685,335	4,686,328	135	104	188
Dist. 7-C W. Central	53	1		54				108	8	116	80	48	452,323	806	389	+107.2	3,228,188	1,748,027	82	86	83
Dist. 8 West	289		2	51	1			343	22	365	343	260	1,914,434	3,537	2,398	+ 47.5	18,938,868	11,776,113	547	509	372
Dist. 9 North	150			111	1			262	3	265	285	240	763,759	2,745	2,187	+ 25.5	7,699,317	5,961,870	196	196	169
Dist. 10 Panhandle	60		67	24				151		151	83	112	475,865	907	919	- 1.3	2,554,327	2,975,214	91	91	110
Utah											5	5		19	51	- 62.7	67,571	257,860	12	8	13
Virginia																			1	1	1
Washington														2			16,032				1
West Virginia	12		28	14				54	2	56	64	37	148,295	548	389	+ 40.9	1,401,512	1,127,500	245	260	222
Wyoming	30		3	26				59	1	60	58	56	291,766	501	503	- 0.4	2,465,911	2,359,561	91	93	90
Total U. S.	2,142	30	361	1,496	77	9	9	4,124	74	4,198	3,954	3,300	15,186,145	36,591	32,143	+ 13.8	132,420,443	114,104,474	4,773	4,633	4,247

An Independent Looks at Today's Oil Economy

An interview with

COL. T. H. BARTON
Chairman of the Board, Lion Oil Company

EDITOR'S NOTE: *The questions which Col. T. H. Barton answers in this interview have been asked by individual oil operators and executives of oil companies which may be classified as "strong independents." While not claiming to do so, Colonel Barton may be said to speak for this important segment of the industry, a task for which he is well qualified because of his outstanding record in building Lion Oil Company into one of the fastest growing, completely integrated independent oil companies in the country. Colonel Barton entered the oil business in El Dorado, Ark., and from 1921-28 was president and director of El Dorado Natural Gas Company and Natural Gas and Fuel Company. In January, 1929, he became president and director of Lion Oil & Refining Company (now Lion Oil Company) and so served until 1947 when he became chairman of the board. Still active in his company's affairs, he also holds directorships in a number of top American companies. He has been recipient of distinguished service awards from the State of Arkansas and from El Dorado, and holds honorary doctorates from the University of Arkansas, Harding College and College of Ozarks. He is a director and member of the executive committee, API; director, IPAA; and is a member of the National Petroleum Council, which succeeded the disbanded Petroleum Industry War Council.*

Q. *Has the shortage of tubular goods affected drilling operations of the average size oil company?*

A. Yes. The gray and the black market have been developing in tubular goods, and the shortage of these materials seriously affects the drilling campaign by many of us who are classed as independents.

Q. *Do you recommend government allocation of steel, and how should allocation be set up?*

A. I think it would be preferable if it were not necessary for the government to allocate steel, but some method must be devised whereby all operators can be equitably furnished tubular and other steel materials that they may contribute to the efforts in the increased supply of oil needed by our defense.

Certainly, allocation should at least be made on the basis of drilling operations of the various companies and individuals during 1950, and every consideration should be given the oil industry, whose products are so vital for the success of our defense plans.

Rather than set up government action on this, I believe that the steel companies could certainly work this matter out with the committee set up from the oil industry headed by such a man as Russell B. Brown of IPAA.

Q. *Do you believe voluntary allocation of tubular goods and other critical materials will work?*

A. Yes, I believe it can work.

▪ CONTINUED ON PAGE 58

COL. T. H. BARTON

Oil Now $32 BILLION Industry

By L. J. LOGAN, Associate Editor

EMPLOYING GROSS ASSETS of $32 billion in the U. S., the petroleum industry has an investment greater than that of any other "industrial" group, although less than agriculture, railroads, and the public utilities. Gross assets will total about $32.4 billion at the end of 1950, following capital expenditures of nearly $2.2 billion for U. S. facilities this year. This represents continuance of postwar expansion that has cost over $10 billion in five years, or an average of over $2 billion per year.

TOTAL investment of the petroleum industry in the U. S. will exceed $32 billion at the end of 1950, including more than $2 billion represented by capital expenditures during 1950. In terms of gross assets employed, the industry continues foremost among regular "industrial" groups, although still exceeded by agriculture, railroads, and the public utilities.

The petroleum industry is making capital expenditures of $2172 million on facilities within the U. S. during 1950, according to a recent survey of the American Petroleum Institute. (In addition, U. S. companies are spending $228 million on facilities outside the U. S., or a total of $2.4 billion for the year.)

This year's huge capital expenditures within the U. S. will be about the same as in other years since the war. For the five years, 1946-1950, these investments in new U. S. facilities have totaled over $10 billion and have averaged a little more than $2 billion per year.

The industry during the past five years has been putting into new facilities three times as much per year as in the preceding five years, having invested a total of only about $3.6 billion or an average of $717 million annually in the five years, 1936-1940. Much of the sharp increase in capital expenditures has been required, of course, to cover greatly increased cost in the postwar period. All of the expansion of the industry's facilities that has been achieved has been needed and now represents a vital asset to the nation. The new and needed facilities justify the recent levels of petroleum product prices and oil company earnings, for they have been financed and made possible largely by dipping deeply into the earnings for funds for construction, improvement, and replacement of facilities, with reserves for replacements inadequate due to inflated costs.

That the petroleum industry's total investment is now about $32 billion is indicated by the API survey considered in conjunction with the estimate of Joseph E. Pogue and Frederick G. Coqueron of the Chase Na-

Summary of Capital Expenditures by the Oil Industry of the U.S.

(Source: American Petroleum Institute)

(MILLIONS OF DOLLARS)

DIVISION	Total Company Estimates 1950	Actual 1949	Actual 1946-49 Inclusive	Yearly Average 1946-49	Actual 1936-40 Inclusive	Yearly Average 1936-40
PRODUCTION:						
Crude Oil—Leases, Wells, Equipment	$ 1,198	$ 1,270	$ 4,758	$ 1,190	$ 2,135	$427
Natural Gas—Leases, Wells, Equipment	57	65	244	61	110	22
Natural Gasoline Plants	74	104	264	66	78	15
All Other, Including Crude and Gas Marketing	31	18	98	24	53	11
Total Production	$ 1,360	$ 1,457	$ 5,364	$ 1,341	$ 2,376	$475
TRANSPORTATION:						
Pipe Lines—Crude Oil Lines	$ 120	$ 143	$ 547	$ 137	$ 180	$ 36
Products Lines	74	31	166	41	49	10
Natural Gas Lines	91	49	166	41	41	8
Total Pipe Lines	$ 185	$ 223	$ 879	$ 219	$ 270	$ 54
Marine	22	81	410	103	204	41
Tank Cars	7	18	49	12	20	4
All Other	10	10	59	15	12	2
Total Transportation	$ 324	$ 332	$ 1,397	$ 349	$ 506	$101
REFINING	$ 394	$ 508	$ 1,827	$ 457	$ 617	$124
MARKETING	281	233	987	247	502	100
OTHER	41	62	196	49	82	17
GRAND TOTAL	$ 2,400	$ 2,592	$ 9,771	$ 2,443	$ 4,083	$817
Facilities Outside of the U.S. Included in Grand Total	$ 228	$ 368	$ 1,389	$ 347	$ 500	$100
Total For Domestic Facilities	$ 2,172	$ 2,224	$ 8,382	$ 2,096	$ 3,583	$717

tional Bank that the total was $30.2 billion at the end of 1949. Their estimate included $23.5 billion as the gross value of the industry's plant, property, and equipment; $6.3 billion in current assets (cash, marketable securities, oil inventories, materials and supplies, etc.); and $4 billion of other assets. With $2.2 billion being spent for additional facilities in the U. S. this year, the total investment or gross assets employed will reach about $32.4 billion at the end of 1950, assuming no material change in current assets; and the gross investment in plant, property and equipment will be up to about $25.7 billion.

In announcing the results of the recent API survey, API's president, Frank M. Porter, said:

"The high level of investments maintained by the oil industry during the postwar years has brought the nation's ability to produce and manufacture gasoline, fuel oil, and other petroleum products to their highest point in history. While this indicates that the oil industry is better prepared now than ever before to meet military and essential civilian demands, it must be recognized that military requirements fluctuate from day to day, and that unpredictable international events can change this picture rapidly. Adequate peacetime transportation, for example, does not necessarily mean adequate wartime transportation."

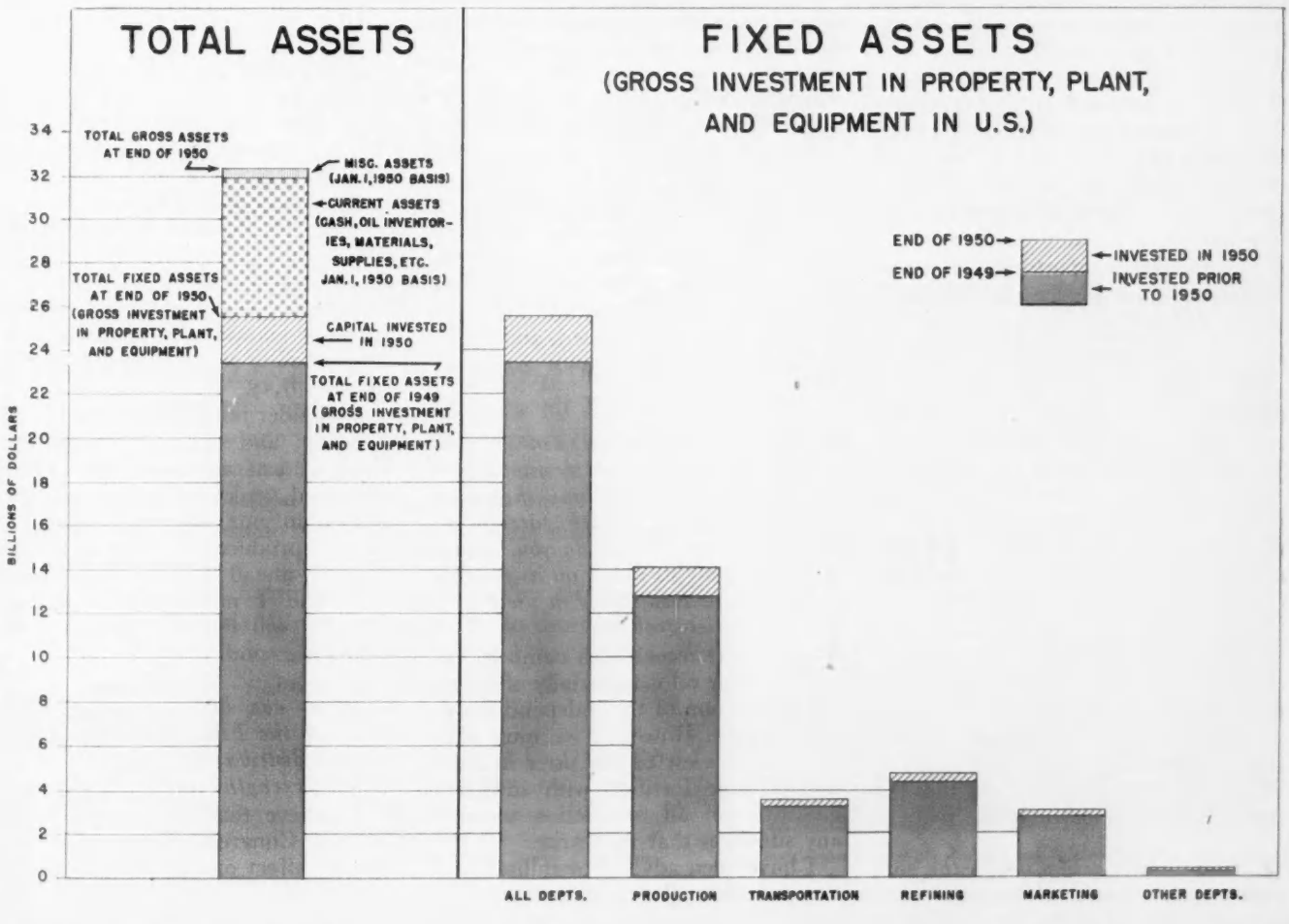
In an earlier recent statement, Porter had pointed out that as a result of the unprecedented industry expansion in postwar years, the oil industry's crude production capacity has been increased 27 percent, its refining capacity 21 percent, and the nation's proved crude oil reserves 24 percent.

Production Expenditures

Of the total of $2400 million being spent in 1950 for facilities, including the $228 million in foreign areas, a total of $1360 million or nearly 57 percent is for production purposes. This includes: crude oil leases, wells, and equipment $1198 million; natural gas leases, wells, and equipment $57 million; natural gasoline plants $74 million; and all other, including crude and gas marketing, $31 million. Production department investment was $1457 million in 1949 and averaged $1341 in the four years, 1946-1949.

For transportation facilities, $324 million will be spent in 1950, about one-eighth of total capital expenditures. This amount includes $120 million for crude oil pipe lines, $74 million for products pipe lines, and $91 million for natural gas pipe lines; $22 million for marine transportation facilities; $7 million for tank cars; and $10 million for all other transportation. Crude line construction is off somewhat from other recent years. But outlay for natural gas lines by the oil industry in 1950 is nearly double the $49 million of 1949 and more than double the average of $41 million annually for 1946-1949. Product pipe line expenditures likewise are increased sharply from the $31 million of 1949 and 1946-1949 four-year average of $41 million a year.

Investments for refinery facilities in 1950 will be close to $394 million, or nearly one-sixth of the total, much of the money going into the latest type cracking plants for producing vital high quality products for domestic requirements and possible military needs. Similar expenditures were $508



million in 1949 and averaged $457 million annually in 1946-1949.

In modernizing, improving, and expanding marketing facilities, the industry will make a record high capital investment of $281 million in 1950. This compares with $233 million spent in 1949 and an annual average of $247 in 1946-1949. These investments mean more efficient and more dependable service to the public.

Completing the total of $2.4 billion of capital expenditures in 1950 is $41 million of "other" facilities, not charged to any one division of the industry. This outlay is less than the total for 1949 or the average for the 1946-1949 period.

Pogue and Coqueron also gave data by departments in estimating gross investment in property, plant, and equipment of the petroleum industry within the United States at $23,500 million for the end of 1949. They showed production department gross investment of $12,775 million, including $11,750 million in leases, wells, and equipment; $725 million in natural gasoline plants; and $300 million in natural gas facilities. For transportation facilities they showed a total of $3300 million, which included: crude oil pipe lines, $1475 million; product pipe lines, $325 million; marine facilities, $1150 million; tank cars, $275 million; and motor transportation, $75 million. Refining department investment was given as $4375 million. In marketing, investment was estimated at $2750 million. Other facilities represented $300 million.

Against the gross investment of $23,500 million in property, plant, and equipment, the Pogue-Coqueron estimates showed that reserves had been set up in the amount of $11,700 million for replacement of wornout or depleted properties, leaving an indicated net investment or net value of $11,800 million.

An Independent Looks at Today's Oil Economy

• CONTINUED FROM PAGE 55

Q. *In the event such voluntary allocation does not work, do you believe the National Petroleum Council should be empowered to negotiate with manufacturers and distributors of tubular goods and other critical materials, with power to force decisions on manufacturers and distributors?*

A. This can work. It occurs to me that it would be far more advantageous for the two giant industries, steel and oil, to handle on a cooperative basis rather than be compelled to resort to government controls and directives in this respect.

Q. *Should national emergency warrant an immediate increase in crude oil production and refined products, in what shape is the average oil company in today to meet such additional demands.*

A. From present reports, our domestic crude oil production, coupled with the foreign crude imports, is sufficient to supply our present demands. But, of course, it will be necessary should our defense action become more active that both crude and refined products should be immediately increased to the extent that is necessary. The industry of the U. S. is in condition to do this. With the exception of alkylates and high octane gasoline, the demands can be met.

Q. *Do you recommend expansion of current refining facilities? Why?*

A. Yes, there is a need for additional refining facilities, explained in my answer above. We must be equipped to give our flying services and those of our Allies additional aviation fuel.

Q. *Is there any action which the government can undertake at this time which will assist the small producer and refiner?*

A. By permitting the industry to operate under the free enterprise system. To permit smaller unitized drilling operations on government land, and to permit the refiner who is compelled to erect additional plants at this time to depreciate his cost on a more equitable basis than now existing. I believe that the government could encourage the addition of refining facilities at this time by permitting a 20 percent depreciation allowance so that these investments for defense plants may be written off in a period of five years.

By permitting the system that prevailed under the approval of the Petroleum Industry War Council and approved by the Petroleum Administrator for War during World War II that a free exchange of raw or manufactured products between producers and other refiners, to the extent that 100 percent of our capacity of refined products may be produced, and freely exchanged, without fear of anti-trust action.

Q. *Are current petroleum imports hurting the independent domestic producer? Do you think a limit should be placed as to how much foreign oil should be imported, or do you recommend shipping as much oil as possible from Middle East fields in view of a possible Soviet grab?*

A. Yes. The recent high climb in imported crude oil is materially affecting the production of the independents in this country. However, we must take an over-all view of the present situation and be fortified with sufficient quantities of oil production to meet any situation that may arise.

I have been advised by military authorities that all armed forces should have greater storage of fuel and other refined products not only in the U. S., but in all sections of the world where we now are, or may be, operating in our defense action.

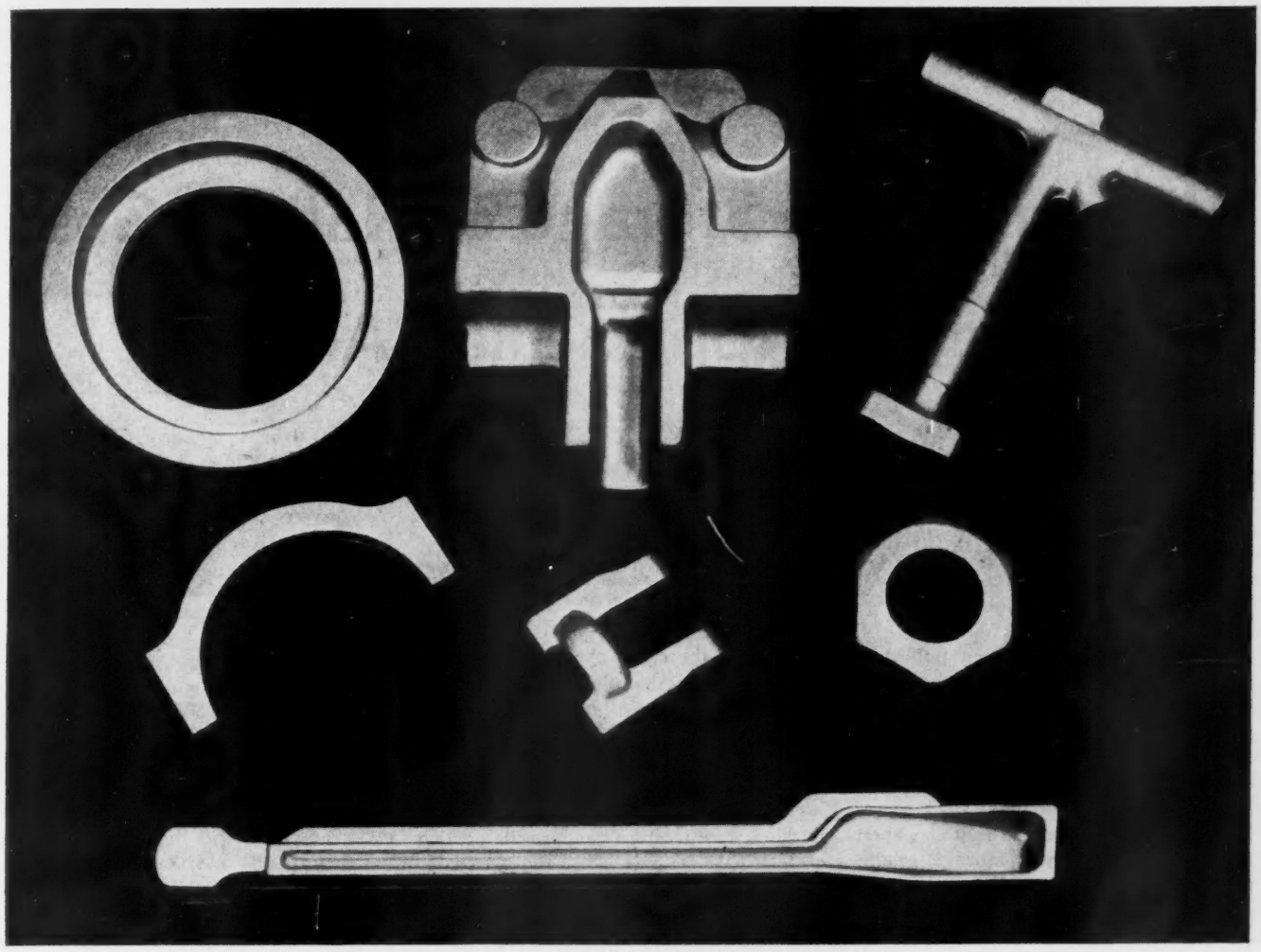
Decidedly, there should be a greater import tax on oil products than we now have. The independent domestic producer is at a great disadvantage when oil is freely permitted to come into this country from other sections of the world where production is unlimited and where, naturally, the production cost is far less than in the U. S. It will be a very unwise policy to penalize the domestic producer to the point where his initiative and exploration and development is curtailed. I realize this is a moot question, but there is certainty in the fact that our domestic exploration and production must be accelerated so that we may at any time be fortified with this vital commodity.

Q. *Which course do you consider more economical? To intensify wildcat activities or to develop known reserves? Why?*

A. I consider both courses sound economically, and of great importance. When wildcat activities are lessened or stopped, we know less of the known reserves in our country, and when any oil producer is not constantly looking ahead by new exploratory work, and I mean wildcat drilling wells, he will find his business in a liquidating condition.

Q. *What can be done to curb the power of the FPC in relation to the sale and distribution of natural gas on an "arm's length" basis?*

A. I believe that the complexion of the new Congress will have a more salutary affect on the authority being absorbed by the FPC.



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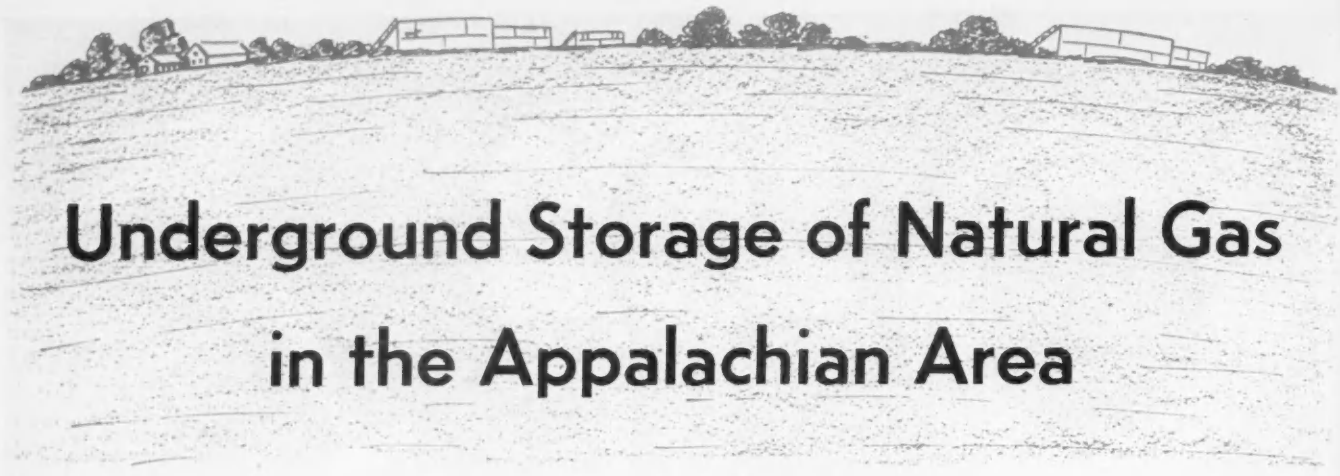

Underground Storage of Natural Gas in the Appalachian Area

By H. J. WAGNER
Engineer Director, Gas Division
Public Service Commission of West Virginia, Charleston, W. Va.

MANY articles have been published during the past few years on the problems of storing gas and of meeting the peak. A number of these articles have contained valuable data on the technical, economic and legal problems involved in storing gas underground and therefore will not be repeated in this paper. However, underground storage operations are changing from day to day, and it is this changing picture that should be interesting to all natural gas operators.

Gas Supply

For more than 50 years all natural gas used in the Appalachian area was produced in Kentucky, New York, Ohio, Pennsylvania and West Virginia. The supply was generally ample to meet the demands except during the few coldest days each year. Early in World War II it was apparent that due to a lack of manpower, materials and the necessary equipment to drill additional wells, natural gas produced in the area would not be sufficient to meet the demands. This resulted in practically prohibiting the extension of gas service to all but essential industry and a decision that the natural gas requirements of the area could best be assured by the construction of a pipe line to the southwest, where a large excess supply of natural gas was readily available. The pipe line was constructed and began delivering 200 million cubic feet of natural gas per day into the Appalachian area late in 1944. West Virginia at that time was producing approximately 50 percent of the natural gas used in the entire area. The pipe line systems of that state's operating companies were so interconnected with the gas systems of companies operating in adjoining states, that gas originating in West Virginia could be delivered to practically all major markets in the entire Appalachian area. By connecting the pipe line from the southwest to the two largest natural gas systems in West Virginia, gas from this line was thereby made available to all parts of the Appalachian area.

At present 3 large pipe lines are delivering southwestern gas into the northeastern part of the U. S. Tennessee Gas Transmission Company's present authorized capacity is 1,060,000 mcf per day with an application pending for additional capacity of 250,000 mcf per day. Texas Eastern Transmission Corporation's present authorized capacity is 740,000 mcf per day, which with a pending application for 425,000 mcf would provide for the delivery of 1,165,000 mcf per day. This includes deliveries of 235,000 mcf per day from the line of Texas Gas Transmission Company. Panhandle Eastern Pipe Line Company is delivering a relatively small volume of gas into Ohio.

Transcontinental Gas Pipe Line Corporation is at present constructing a line which will also deliver natural gas from the southwest into the eastern markets. This company's authorized capacity is 340,000 mcf per day, with an application pending that will increase its delivery capacity to 505,000 mcf per day. It is evident, therefore, that there will be available at least 2½ billion cubic feet (part of the pipe line capacity will be used to supply markets between the producing area of the southwest and the eastern markets) of natural gas per day from the southwest via pipe lines now constructed or contemplated.

This gas will be supplied to communities whose gas systems will be integrated with or supplied from the same source as the natural gas systems that formerly supplied the old so-called Appalachian area. The construction of these long pipe lines requires the investment of millions of dollars, upon which a return must be earned if the companies are to remain financially healthy. To do this the pipe line company must sell its gas at a high load factor or make limited sales at a higher rate per mcf if the fixed charges are to be spread over the smaller volume of gas. Most, if not all, of the rates contained in the purchase gas contracts are 2 part (demand, commodity) type rates, and many specify a minimum quantity that the purchaser must take or pay for if not taken. This places on the purchaser the responsibility of so balancing his take that he can secure the gas at the lowest possible price.

STORAGE OF natural gas in depleted or partially depleted gas or oil sands is being used increasingly in the Appalachian area, in helping to meet peak demands of winter. This storage of gas underground is an essential and practical operation, at least for companies drawing on distant gas fields for supplies. At present, this appears to be the most economical way known for taking care of peak demands.

Load Characteristics

During the many years that natural gas has been used in the Appalachian area, supply and demand have been fairly well balanced. There is, because of the price at which gas was available, a relatively high saturation of house heating and a large industrial load (not sold at dump gas prices). The domestic load, because of the high saturation

of space heating, even in this part of the U. S., has a low average annual load factor, making it a rather difficult load to serve. However, by limiting deliveries to industrial customers during the few coldest days of each heating season, taking all available gas from the wells, and in later years by the use of underground storage fields, gas companies were able to meet the requirements of the area in a generally satisfactory manner.

More recently, however, due to the change that has occurred in the price of competitive fuels and the trend to a so-called higher standard of living prevailing throughout the country, the demand for natural gas for house heating both for new houses and for conversions has been terrific. The distributing companies are months behind in making the necessary line extensions, reinforcements, and other things that must be done to supply this increased market. In addition there has been some decrease in the use of natural gas for industrial purposes. This decrease in industrial gas sales and the increase in the use of natural gas for heating, in the Appalachian area, have added to the headaches of the operators.

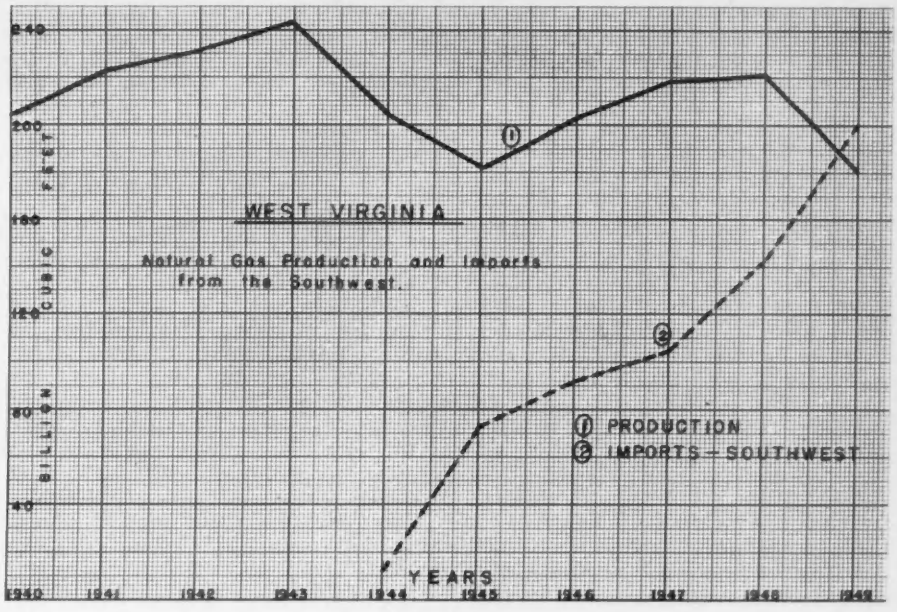

FIGURE 1

Authorized Deliveries

Deliveries have recently been authorized to Philadelphia, Baltimore, and New York City, not to mention many other cities and towns in the northeastern part of the U. S. A new company has been organized and has applied to the Federal Power Commission for a certificate of convenience and necessity authorizing it to construct facilities to deliver natural gas to 6 New England states. Part of the natural gas (100,000 mcf per day) to be supplied to the New England states by this company is to be furnished by Transcontinental Gas Pipe Line Corporation and the remaining requirements for the New England markets, which this company contemplates serving, are to be supplied by Tennessee Gas Transmission Company. Texas Eastern Transmission Corporation has also filed an application with FPC, which, if granted, will supply markets in New Jersey, Connecticut, Rhode Island, Massachusetts and New Hampshire.

However, due to the higher price at which the gas will be sold in these states, it is not likely that the balance which existed in the older markets between the domestic and commercial load on the one hand and the industrial load on the other will be maintained. Unless a way is found to lower the peaks and fill in the valleys in the load curve, the headaches which the operators are presently experiencing will seem mild in comparison to what is in store for them in the future. In most cases the operating companies intend to distribute a mixed gas or to use the natural gas to produce a higher British thermal unit sendout gas. Many of the contracts under which natural gas is to be supplied to these new areas specify the maximum volume which the supplier must furnish, and in some cases the distributing companies have agreed to do a certain amount of peak shaving. What happens in such cases following the introduction of natural gas is common knowledge.

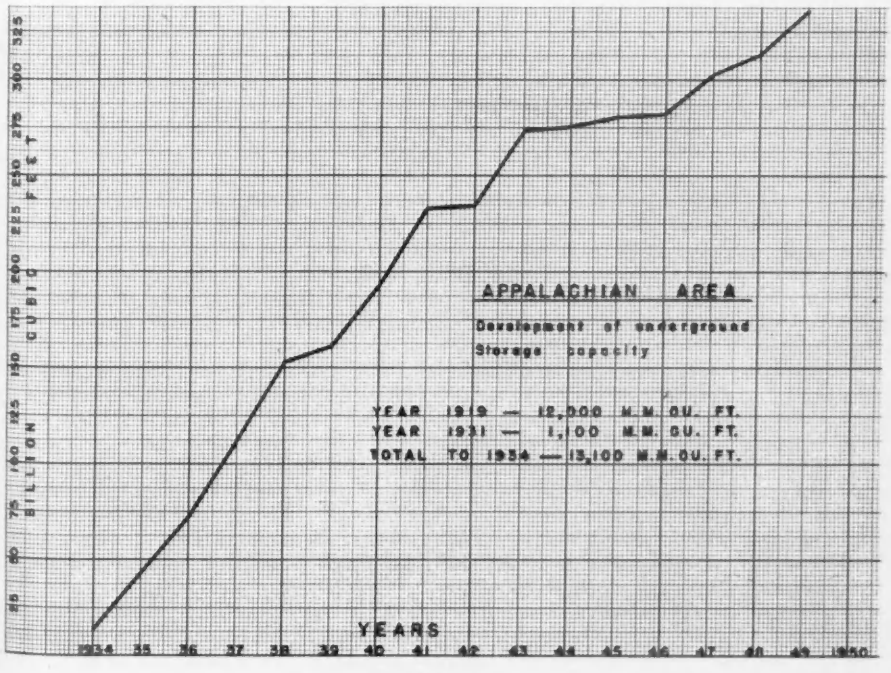

FIGURE 2

Storage Operations

Gas companies store gas for 3 reasons: (1) to have gas quickly available where and when needed, (2) as a means of improving the system load factor both on the production and transmission plants, and (3) to improve the load factor at which gas can be purchased, thereby obtaining a lower price. Figure 1 shows the gas produced in West Virginia and southwest pipe line gas being delivered into West Virginia. It shows that during 1949 more than half of the state's gas supply was southwestern pipe line gas. Similar data for the entire Appalachian area have not been compiled but would show that a large part of the gas supply for the entire area is now coming through pipe lines from

the southwest. As the distance between the source of supply and the load center increases, the load factor problem becomes more important. How important this question is at present, with a large part of the gas supply coming from the southwest, is apparent from the accompanying resume of the methods for storing gas that are either being used or are under investigation at the present time. (Table I.)

The storage of natural gas in abandoned mines has also been suggested.

Development of underground storage operations in the Appalachian area is shown in Figure 2. Some work was done on this problem as early as 1915 or 1916. However, data on this early development are not available. Of the pools currently in use, 1 was first used in 1919; 1 was started in 1931, 1 in 1934 and 7 in 1936. Beginning in 1936 and continuing through 1949, at least 1 pool was put into operation each year. In several of the years as many as 7 pools were developed. The curve shows by years the storage capacity of the pools at the end of the year, estimated if not known. This capacity is the present capacity of the pools; not the capacity as it may have been originally estimated. Data shown are for 72 pools. Fifteen additional pools, for which the detailed data are not available, are known to be in use in the area. From conversations with other local operators we also know that many of them are in reality storing natural gas in 1 or more wells, but these operations are not considered by the owners to be of sufficient importance to report them. All in all, there are at least 100 storage projects either in use or under investigation in the Appalachian area at the present time.

The total storage capacity of the 72 pools known to be in operation or under investigation at present is 334 billion cubic feet.

As of November 1, 1949, these pools contained more than 224 billion cubic feet of gas, and are estimated to have had a daily delivery capacity of at least 2.6 billion cubic feet.

About the Author

H. J. WAGNER is an authority on underground storage of natural gas and liquefied petroleum gases. He has been particularly active, as engineer director of the gas division of the Public Service Commission of West Virginia, in promoting measures for conservation of the natural gas resources of his state. As West Virginia representative on the Interstate Oil Compact Commission, he has given strong support to measures pertaining to oil and gas conservation. Hs is a graduate of Bucknell University with B.S. in electrical engineering and M.S. degrees. Wagner has written numerous articles relating to natural gas. Many of the articles have been published in technical and trade journals.

Cost of Storing Gas

We have heard a lot about the cost of storing gas. Max Ball, in a paper presented at the 1949 meeting, Natural Gas Department of the American Gas Association, said "The *investment costs* reported to us for underground storage range from 2 to 53 cents per mcf of usable capacity." It has been said that storage gas costs more than $1 per mcf, but the writer has not seen figures that substantiate such a high cost. It is questionable whether anyone knows exactly the additional cost incurred in storing gas. This is true because few, if any, of the large companies have reached steady operation of storage facilities. As shown by Figure 2, available storage capacity has been increasing each year. This, in many cases, involves acquiring new leases, drilling additional wells, laying new pipe lines, installation of measuring and regulating equipment, installation of additional compressor capacity, and in some cases, installation of dehydration equipment, all of which results in an increase in investment. Development of a new storage area also requires a complete investigation and study of the area, reconditioning of old wells, pipe lines, and other equipment. In many cases all equipment must be reconditioned to withstand the higher pressure that will be used. In addition, the volume of cushion gas (the gas that is kept in the pool to give a higher deliverability rate) has been increasing, and this results in higher carrying charges. All of these factors have made it difficult, if not impossible, to determine accurately the added cost of gas that has been handled through storage. The fact that companies which started storing gas 10 or more years ago are today adding to their storage capacity indicates that it is cheaper to store gas than to provide peak load gas by building additional pipe lines and operating these pipe lines at a low load factor. Recently, the writer had an opportunity to check the storage operations of one of the large companies operating in the Appalachian area. It was found that the average cost for the particular year was 7½ cents per mcf. This includes return on the investment, a carrying charge on the cushion gas, both at 6 percent, plus operating charges, including a portion of general administrative expense. The company is still adding to its storage capacity and increasing the amount of cushion gas. Under settled operating conditions, therefore, the average cost may be slightly higher or lower than 7½ cents per mcf.

From this discussion of the problem it is apparent that the storage of gas in depleted or partially depleted gas and/or oil sands is an essential and practical operation, at least for those companies that obtain part of their gas supply from distant gas fields, and that at present it is the most economical way known for providing peak load gas.

TABLE 1

Methods of Storing Gas and Extent of Use in Appalachian Area

Type of Storage	Extent of Use
1. *Underground storage in depleted or partially depleted oil and/or gas sands.	Widley used.
2. Underground storage of gas in sands which have not produced oil or gas.	Limited use and under study.
3. Liquefaction, storage, and regasification of natural gas.	One company storage capacity 400,000 Mcf. Liquefaction 4,000 Mcf daily. Regasification 6,000 Mcf/hour.
4. Storage of gas in or on granular methanite in an above ground container.	Recently started by one company.
5. Underground storage in a "gas sand" of a mixture of LPG gas and natural gas.	This type operation has recently been used by at least one company.
6. Storage of gas at high pressure in buried sections of pipe.	One company has been using this type storage for some time.
7. Storage of natural gas in the form of a hydrate....	Has been under study.

* Both natural and manufactured gas are being stored.

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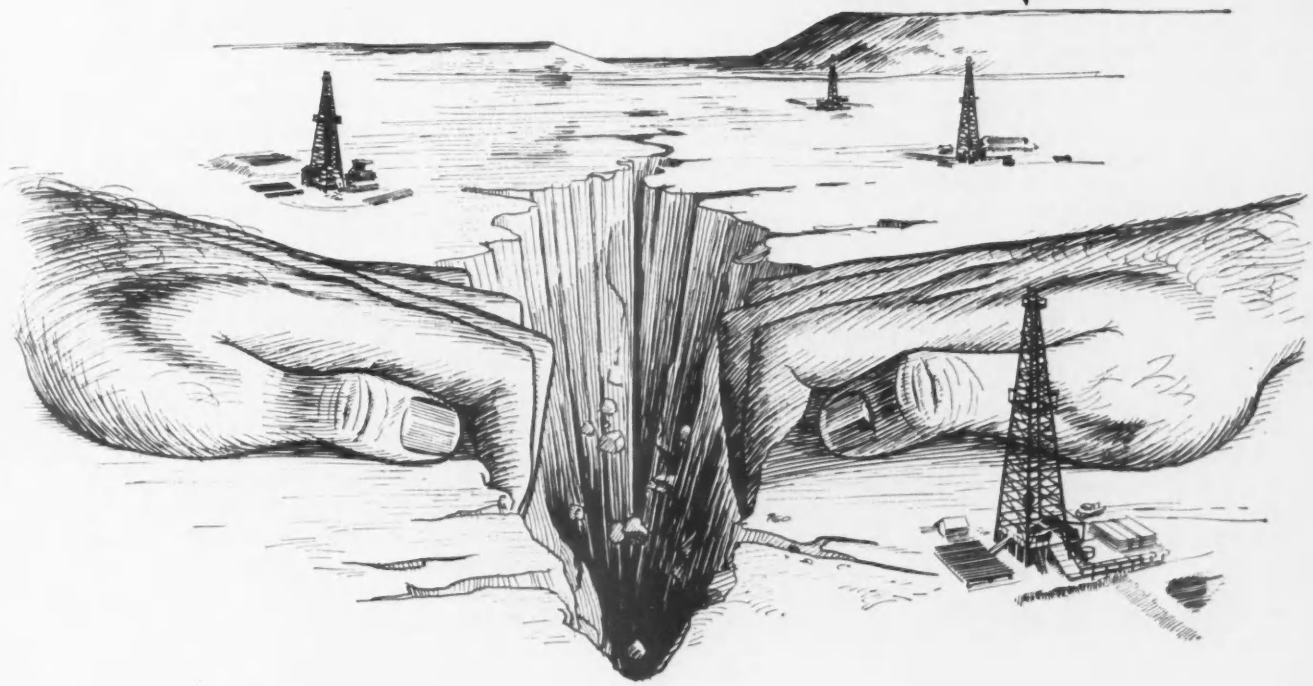

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PETROLEUM RESERVOIR ENGINEERING

Helium . . . and its Uses

By

R. A. CATTELL *and* HENRY P. WHEELER, JR.

Chief, Petroleum and Natural Gas Branch — Petroleum Engineer

U. S. Bureau of Mines

HELIUM is no longer a rare gas in the sense that it is scarce or expensive. The Bureau of Mines, U. S. Department of the Interior, can produce enough helium from natural gas that will go to fuel markets, whether or not the helium is removed, to meet a peacetime demand almost twice as great as the present demand. Large additional quantities can be produced from the government's reserves of helium-bearing natural gas. The purchase price of helium from the Bureau of Mines is only about 1½ cents per cubic foot.

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PRODUCED FROM natural gas, helium is available in ample amounts to meet prevailing and prospective demands, being neither scarce nor expensive. Helium's uncommon properties provide the basis for its growing use for numerous purposes. The rate at which helium grows in importance will depend largely on the rate of dissemination of knowledge concerning its properties, and availability.

Properties of Helium

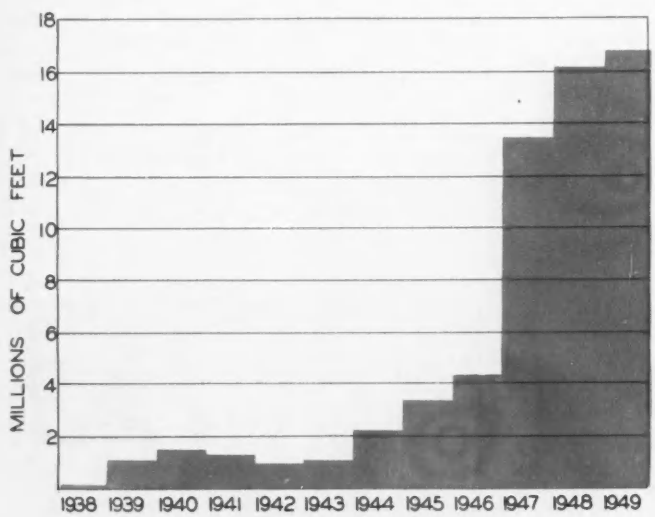
Helium is a rare gas in the sense that it is unique. Its properties are uncommon and provide the basis for its growing usefulness. It is a member of a family of normally gaseous elements that are commonly called "noble" gases because of their extreme chemical inactivity. It has an atomic weight of four; and, at normal atmospheric pressure and 60° F., 1000 cubic feet of helium weighs about 10½ pounds. As air under the same conditions weighs about 76⅓ pounds per 1000 cubic feet, the net lift of helium in air is about 65⅚ pounds per 1000 cubic feet. This amounts to about 92⅔ percent of the lift of hydrogen in air, which is nearly 71 pounds per 1000 cubic feet.

Helium is colorless, odorless, and tasteless. It diffuses more rapidly, flows through an orifice faster, conducts heat better, and transmits sound at a higher velocity than any other gas except hydrogen. It conducts electricity better than any other gas except neon. It has a lower solubility in water and other liquids, a lower refractive index, and a lower temperature of liquefaction than any other gas. The rate of ionization of helium when bombarded with electrons is slower than that of any other gas.

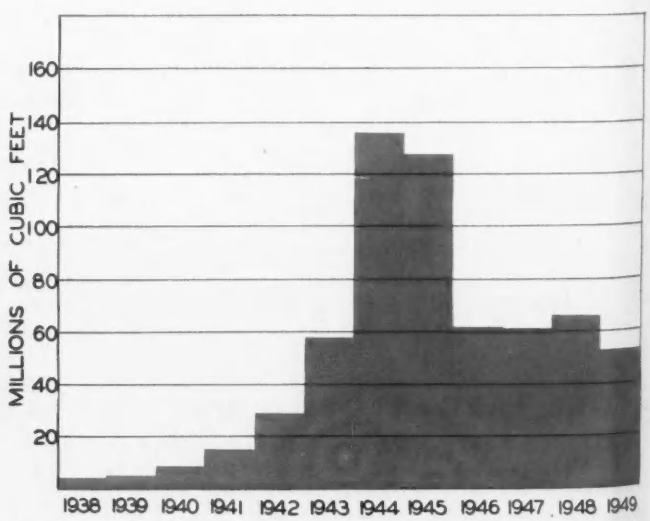
Helium, like hydrogen and neon, has a negative Joule-Thomson effect at ordinary temperatures; that is, it becomes warmer upon being expanded through an orifice, instead of cooler like most gases. The temperature at which the Joule-Thomson effect for helium changes from negative to positive is very low.

Liquid helium exists in two forms—Helium I and Helium II—and is one of the most remarkable substances known. It has a density of only 0.23 gram per cubic centimeter at its boiling point, 268.9° below 0° C (—452° F.). The viscosity of liquid helium at 271.9° below 0° C. (—457.4° F.) is only 1.24 micropoises. The viscosity of water at 20° C. is about 10,000 micropoises. At the same temperature, liquid helium conducts heat better than any other known substance.

Helium has been solidified at 272°

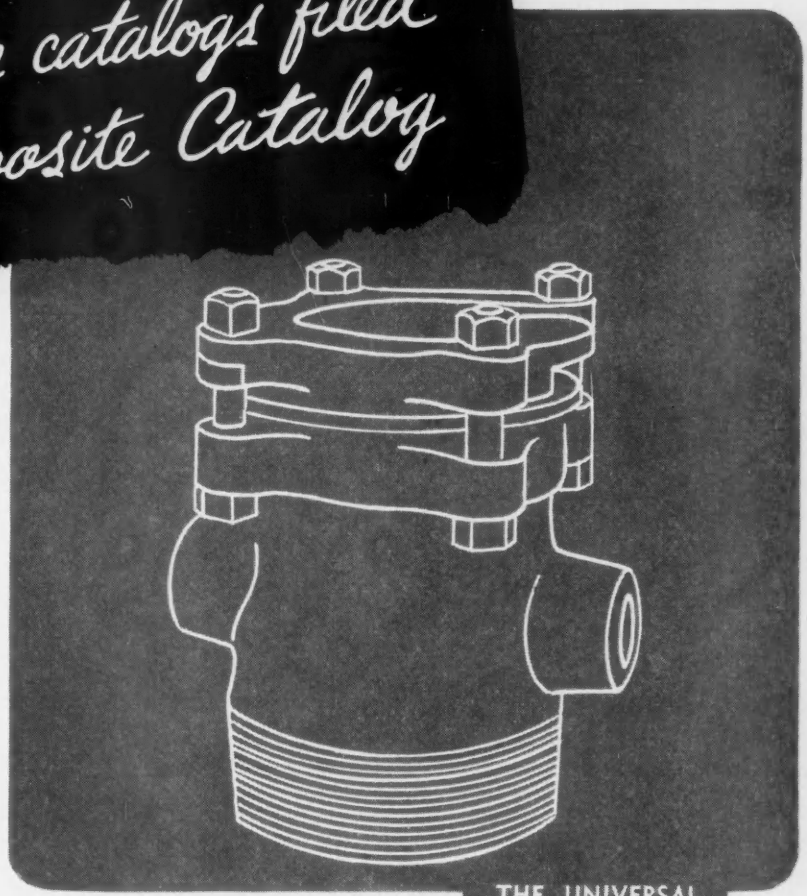


Annual helium sales to non-federal, commercial, scientific and medical customers during 12 fiscal years. A peak of 16,554,000 cubic feet was reached in 1944.



Annual total production of helium during the 12 fiscal years which began in 1938 and ended June 30, 1949. A peak of 137,268,000 cubic feet was reached in 1944.

22 Casing head Manufacturers have their catalogs filed in Composite Catalog



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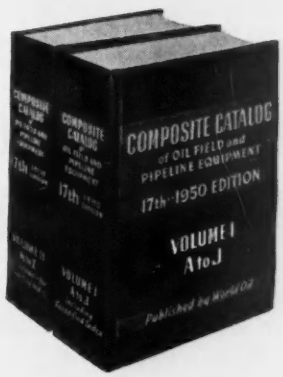
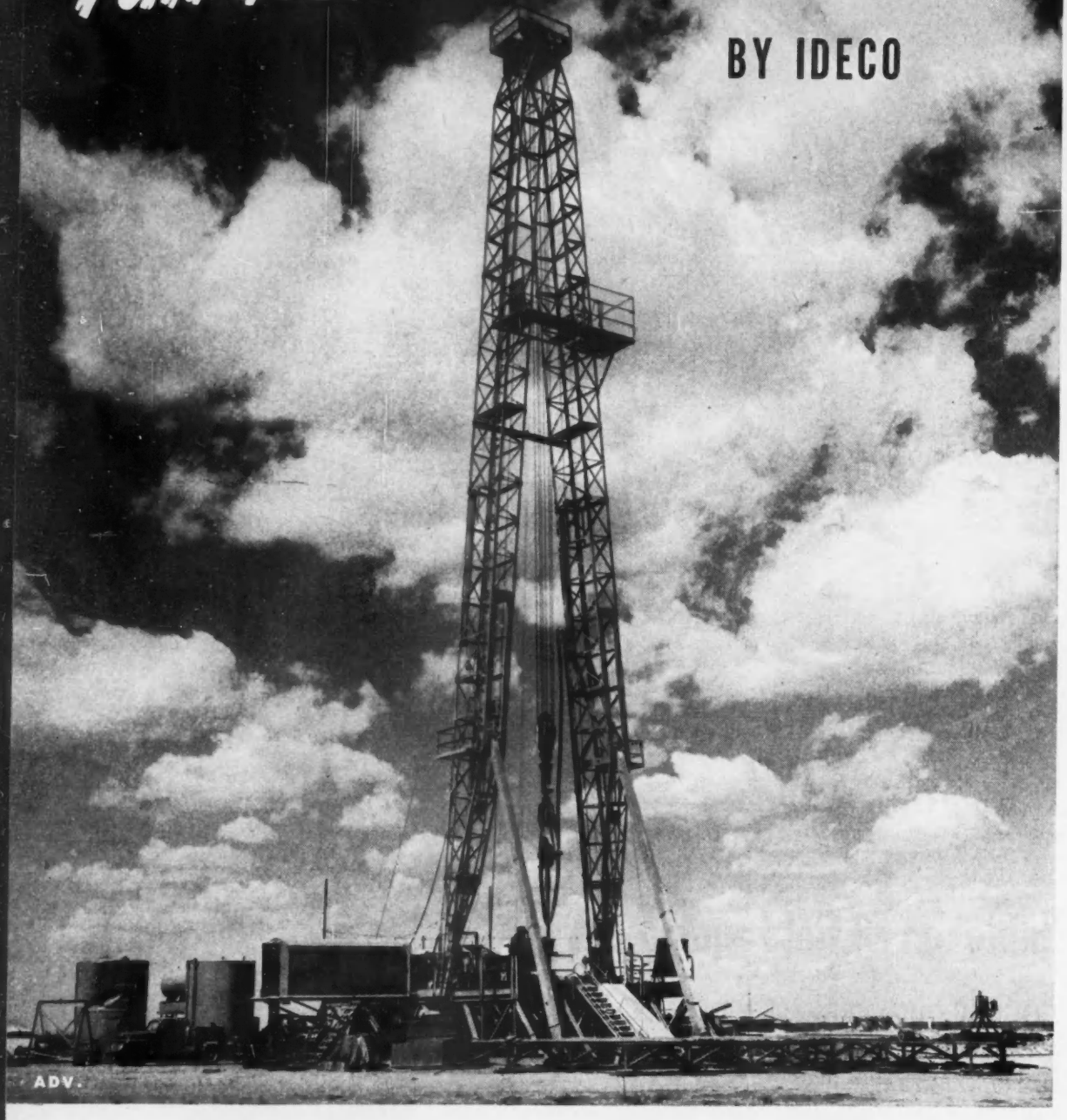


COMPOSITE CATALOG

DESCRIPTIONS OF NEW EQUIPMENT IN THIS ISSUE OF WORLD OIL ARE SUPPLEMENTS TO THE MANUFACTURERS' PRE-FILED CATALOGS IN THE COMPOSITE CATALOG

Full View Mast

BY IDECO



THE FULL-VIEW MAST CUTS DRILLING COSTS, OFFERS MORE FLOOR SPACE AND GREATER STABILITY.

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Full-View Masts are "A" frame structures (no guys). No braces or girts obstruct the driller's view of the traveling block or derrick man.

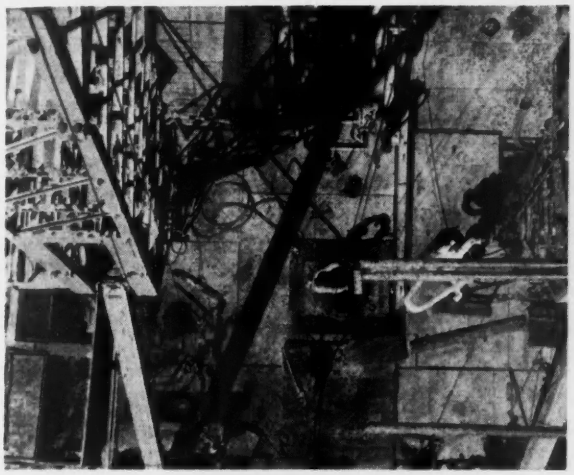
The widespread legs permit the use of any type or size drilling rig and provide plenty of clear space around the catheads. The large drilling floor measures 24′ from drawworks to pipe ramp and 27′8″ from side to side.

Raised by means of the traveling block, the *Full-View Mast* is virtually pushed upward to drilling position by a pair of raising legs, pivoted at ground level. Automatic safety locks are engaged by the raising legs as the mast approaches vertical, holding it in an upright position. It is positively secured by setting manual lock jacks. Easily and quickly raised, the *Full-View Mast* has the additional safety factor of not going over center when erected.

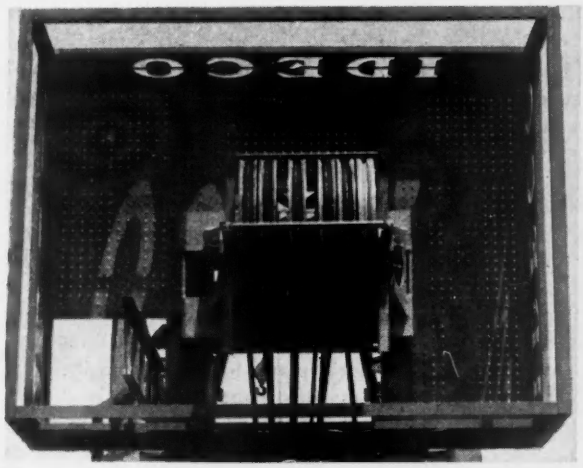
The *Full-View Mast* obtains its unusual stability from the widespread placement of the four legs and the latticed-box construction of the two main mast legs.

The mast has been designed for ease of movement. For field moves, the entire rig, with mast erect, may be skidded between locations; or the mast may be lowered to horizontal, removed from the base and transported in one, two or four loads.

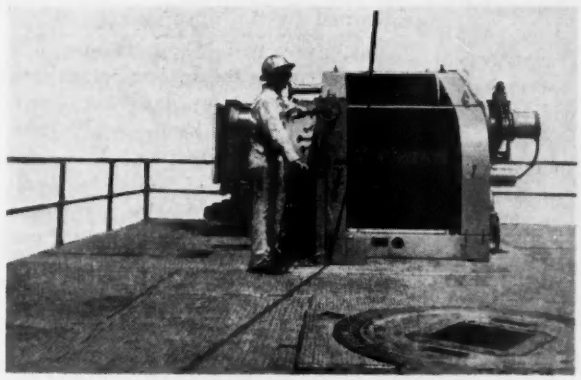
More detailed information is available upon request. Write to Department 215, International Derrick and Equipment Company, Dallas 1, Texas.



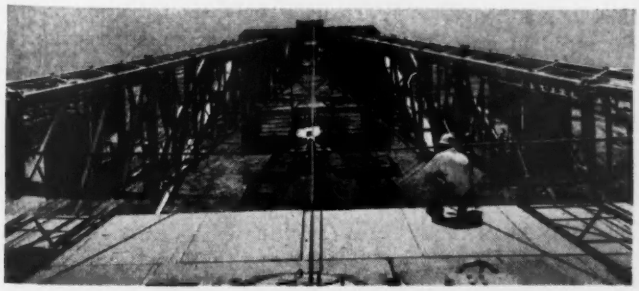
THE DERRICK MAN HAS A FULL VIEW OF ALL OPERATIONS ON THE DRILLING FLOOR.



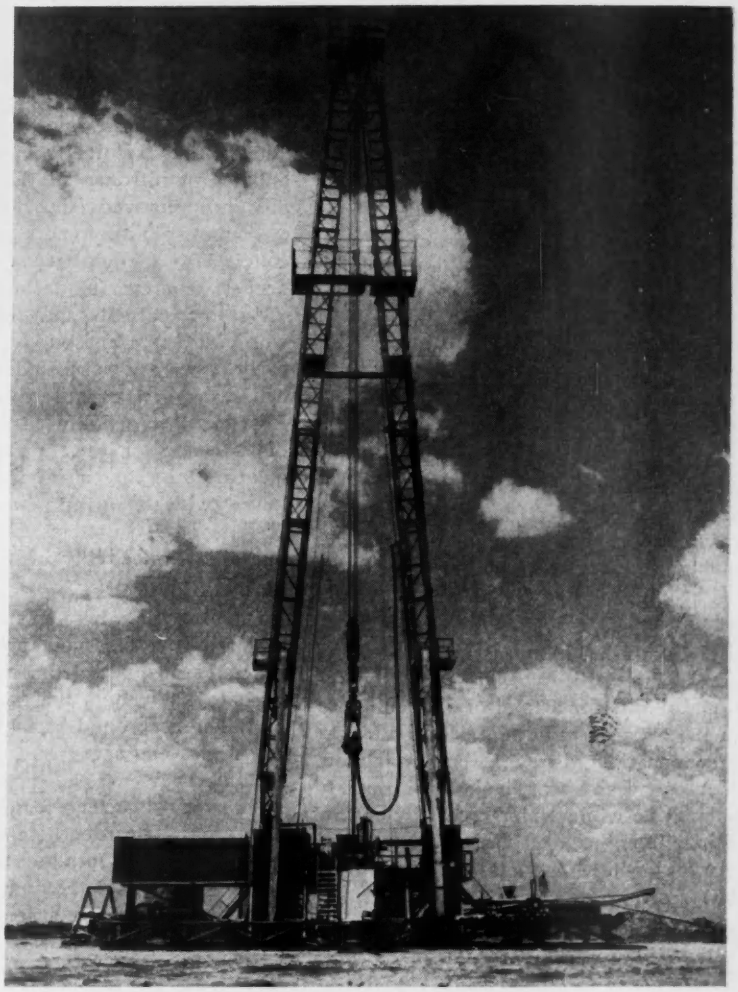
SHEAVES ARE MOUNTED ON A SINGLE CENTER PIN PROVIDING EQUALIZED LOADING ON THE MAST LEGS.



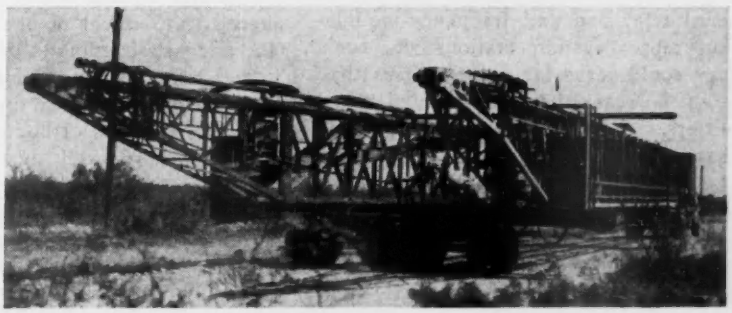
WIDE SPREAD LEGS PERMIT THE USE OF ANY TYPE OR SIZE DRILLING RIG AND PROVIDE PLENTY OF CLEAR SPACE AROUND THE CATHEADS.



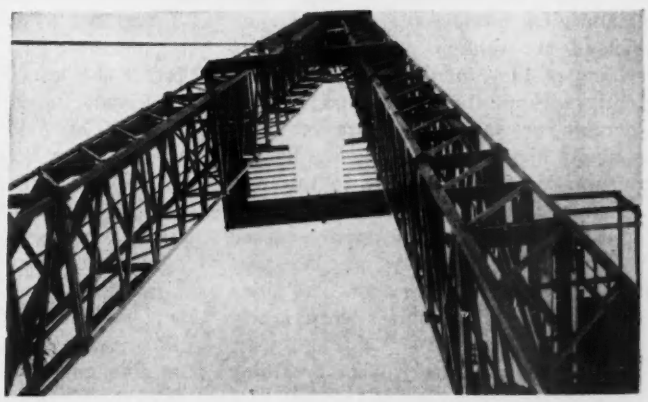
DURING THE ENTIRE RAISING OR LOWERING OPERATION THE DRILLER HAS PERFECT VISIBILITY AND CONTROL.



FULL VIEW DESIGN GIVES EXCEPTIONAL RIGIDITY AND VISIBILITY.



WHEN MOVING, THE MAST CAN BE TRANSPORTED WITH THE LEGS OPEN AS SHOWN OR THEY MAY BE DRAWN TOGETHER TO FORM A 7'6" WIDTH LOAD.



RACKING PLATFORM AND CROWN BLOCK AS SEEN FROM THE DRILLER'S POSITION.

(Advertisement)

below 0° C. (—457.6° F.) and 26 atmospheres pressure; but, because it is unstable, few properties of solid helium have been determined.

Utilization of Helium

Although helium was discovered on earth by Ramsey in 1895 and in natural gas by Cady and McFarland in 1905, it was not put to practical use until World War I. There wasn't enough helium available in 1917 to fill a toy balloon; but the need for an inert lifting gas was great. Experimental plants were built first in Canada and later in Texas for the production of helium from natural gas. The Canadian plants produced approximately 60,000 cubic feet of relatively impure helium and the Texas plants about 200,000 cubic feet. The combined volume was not enough to affect the outcome of the war, but the feasibility of helium production in quantity was established.

Helium-filled blimps established a fine record in World War II—55,900 operational flights for a total of 550,000 hours in the air with only one airship and one crewman lost through enemy action. Not one vessel was sunk by an enemy submarine while under escort by an airship, although 50,000 ships were escorted in areas where U-boats were known to be present.

Since the war, blimps inflated with helium have been used for many purposes, such as advertising, spotting schools of fish, and rescue missions. They have been suggested for use as aerial television and frequency-modulation rebroadcasting stations. As such, they could serve far greater areas than might be reached by earth-bound transmitters.

Helium-filled aerological balloons provide data for the Weather Bureau, and helium-filled toy balloons are safe playthings for the American child.

Another important use of helium is to provide an inert gaseous shield to exclude oxygen and other active elements from molten aluminum, stainless steel, magnesium, copper, titanium, and other metals and alloys during welding and other metallurgical processes. The helium-shielded arc-welding process permits welding of these metals easily and efficiently without the use of flux or considerable prewelding preparation. The relatively high level of peacetime helium consumption is due largely to this use.

Helium is used to fill space between optical lenses to reduce distortion caused by bending of light rays as they pass from one medium to another. The index of refraction of helium is very nearly unity.

Helium is used to provide breathing atmospheres for divers and others who must work with their bodies subjected to relatively high pressures. Because of the low solubility of helium in blood and body tissues, and the rapidity with which it diffuses, helium mitigates the painful and sometimes fatal caisson disease. This illness, known to divers as "the bends," results from formation of bubbles of nitrogen in the blood when men are removed from an atmosphere of compressed air to normal atmospheric conditions. Helium was used in the deepest dive ever made in a diving suit.

Asthma patients and other persons who, for some reason, find it difficult to breathe, are permitted to breathe a helium-oxygen mixture instead of air. Because of the lightness and high rate of diffusion of the mixture, a larger quantity of oxygen is drawn into the lungs with a given muscular effort. Helium is also used as a diluent to reduce the explosibility of anaesthetics in hospitals.

In oil fields where gas is injected to maintain the reservoir pressure or for other reasons, petroleum engineers often wish to know how the gas spreads out in the underground formations. Bureau of Mines engineers have developed a technique to use a small volume of helium as a tracer element in the injected gas. It can be detected easily and rapidly in gas produced from other wells in the field. Helium is used also as a tracer in piping systems and in detecting leaks in vessels or piping.

Occurrences of Helium

Although helium occurs in the atmosphere to the extent of one part in 186,000, and small amounts occur in radioactive minerals, meteoritic iron, and mineral springs, by far the greatest recoverable volumes of helium are in natural gases produced over widely distributed areas in the U. S. However, helium is present in enough quantity to permit economic extraction in only a few localities. The best-known sources of supply are in the Texas Panhandle, northwestern New Mexico, Kansas and Utah.

The Cliffside gas field which serves the Amarillo, Texas, helium plant 1.8 percent of helium by volume. An incombustible gas containing 7 to 8 percent of helium is produced from the Rattlesnake field in northwestern New Mexico. This field supplies helium-bearing gas to the Navajo helium plant near Shiprock. Helium-bearing natural gases from the best sources in Kansas contain 1 to 1.5 percent of helium, which is slightly more than the helium content of gas from the Channing area of the large Panhandle gas field north of Amarillo; however, the volume of helium in the Panhandle field is very great. Gas from the Channing area is available to the Exell helium plant. Helium also occurs in several Canadian provinces, but these occurrences, like all others known to exist outside the U. S., are of minor importance.

There are four Bureau of Mines helium plants in the U. S. The only one now in operation is at Exell, Texas, north of Amarillo. Its rated capacity of 60 million cubic feet of helium a year will meet present demands for helium. This helium comes from natural gas that is distributed to fuel markets, whether or not the helium is removed.

Another plant in standby status at Otis, Kansas, also is on a pipe line which serves fuel markets; and this plant probably will be the next one put into operation should the demand for helium require it.

The Bureau of Mines Navajo helium plant near Shiprock is in standby status. The helium-bearing natural gas reserves available to this plant are controlled by the government and are being conserved for future use. The natural gas will not support combustion and there is no demand for its use as a fuel gas.

The Bureau of Mines plant at Amarillo is inoperative but serves as field headquarters for the entire helium organization. Here, research is conducted to determine new and better ways to produce and utilize helium. A two-inch high pressure line delivers helium from the Exell plant to loading facilities at the Amarillo plant where it is distributed via truck and rail freight in cylinders resembling those used for oxygen but painted in distinctive orange and black. The helium-bearing natural gas reserves available to the Amarillo plant are owned by the government.

Thus, Bureau of Mines helium facilities are adequate to supply a great peacetime demand without depleting helium reserves that might be needed to meet an emergency. Figures 1 and 2, showing the annual volumes of helium produced and the volumes sold to non-federal commercial, scientific, and medical purchasers for the past 12 years, illustrate a stabilization of helium production since the war, and a growing demand by private enterprise.

If the public can become convinced that helium is not hard to get or expensive, the future of helium seems to be secure; the rate at which it grows in importance will depend largely upon the rate of dissemination of knowledge concerning its properties and availability.

A recent bibliography compiled by the Bureau of Mines[1] lists more than 2600 articles concerning helium. These references include many articles that were written by some of the world's greatest scientists—Bethe, Cleve, Collie, Compton, Crookes, Curie, Dewar, Jacyna, Kapitza, Keesom, Langmuir, Lockyer, Meissner, Millikan, Nernst,

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Onnes, Priestley, Ramsey, Rayleigh, Rutherford, Soddy, Travers, Wilhelm and Zelmanov, to name a few. An article, "Helium—the Wonder Gas" by the senior author of this article, appeared in the *Scientific Monthly* for October, 1949 (p. 222).

Production Process

Helium will not liquefy until a very low temperature is attained. This property provides the basis for its separation from other constituents of natural gas. Nitrogen and the various hydrocarbons in the gas are liquefied in the helium production process and helium is removed in the gaseous state.

In the Bureau of Mines plants helium-bearing natural gas entering the separation equipment should be at a pressure of about 600 pounds per square inch, and if the incoming pipe line pressure is not that great, the gas is compressed in direct-connected gas-engine-driven compressors. Then it is pretreated to remove carbon dioxide and water vapor which might plug the small tubes in extremely cold interchangers and vessels that make up the separation units.

Carbon dioxide and water vapor are removed in a bubble tray tower (contactor) by absorption with a solution of monoethanolamine, diethylene glycol, and water. If hydrogen sulfide is present in the gas, it also is absorbed in this process. The enriched solution then is heated to approximately 270° F. in another bubble-tray tower (still) where the absorbed gases are released. Thus, the solution may be used repeatedly. To assure almost perfect dehydration, gas leaving the absorption tower is passed through a drier containing beds of 4-8 mesh activated bauxite. These beds are reactivated at a temperature of about 350° F.

The natural gas, dry and containing no carbon dioxide, is conducted to the separation area through suitable piping. Here it passes through heat-exchange equipment and is cooled by outgoing gas to about —220° F. Then it is throttled into a crude-helium separator, which is operated at about 200-250 pounds per square inch and —230° F. Under these conditions, the natural gas is about 98 percent condensed; and the gas phase consists of about 50 percent helium and 50 percent nitrogen. This mixture is called crude helium. It is withdrawn from the top of the separator, and liquid is taken from the bottom at rates suitable to maintain the liquid level constant and to sustain the purity of the crude helium. The liquid is throttled to a pressure of about 70 pounds per square inch and passed back through the heat exchange equipment, where it is re-evaporated to cool incoming gas.

If necessary, the outgoing gas is compressed to permit its delivery into pipe lines or other outlets. At the Exell helium plant, compressor cylinders are so arranged that each engine performs both compressor services; one cylinder compresses gas into the plant from the pipe line pressure of 250 pounds per square inch to 600 pounds per square inch, and another cylinder on the same engine compresses it from 70 pounds per square inch back into the pipe line at 250 pounds per square inch. A block gate valve in the pipe line diverts gas through the plant and prevents recirculation.

Crude helium, leaving the separator at a pressure of 15 pounds per square inch absolute, is passed through a heat exchanger (helium interchanger) into piping leading to motor-driven four-stage helium compressors. A large gas holder floats on this line, so compression of the crude helium and subsequent purification need not be at the exact rate of crude-helium production. The compressors increase the pressure to about 2700 pounds per square inch and the crude helium goes back to the separation equipment for further purification.

Here water vapor picked up from the gas holder is removed in a vessel filled with nut caustic, and the crude helium is cooled by passage through the helium interchanger mentioned previously. It is directed into coils of tubing immersed in liquid nitrogen and finally into a small vessel surrounded by liquid nitrogen. The small vessel, together with the vessel surrounding it, is called a helium purifier. The small vessel alone is called a helium-purifier pot. Here at about —310° F. and 2700 pounds per square inch, virtually all the nitrogen in the crude helium liquefies. It is withdrawn from the bottom of the pot and throttled into a vessel called a nitrogen maker. This vessel is operated at the same pressure as the crude-helium separator, and a pipe connects the vapor space of the two vessels. Thus helium that is dissolved in liquid nitrogen taken from the purifier pot is released from solution and recaptured in the crude-helium separator. Substantially helium-free liquid nitrogen from the nitrogen maker is transferred to the shell surrounding the purifier pot.

Helium of approximately 98.2 percent purity is removed from the top of the purifier pot. Until recently this was the grade of heium produced, but developments in helium-shielded arc-welding and other metallurgical processes require that helium of extremely high purity be made available. Rather than handle several grades of helium, the Bureau of Mines added additional equipment to the helium plants, and soon helium substantially 100 percent pure will be the only grade produced. This grade of helium already is available in quantity to any industry or government agency which requires it.

In the final purification step, 98.2 percent helium at a pressure of 2700 pounds per square inch is passed through activated charcoal surrounded by liquid nitrogen. Here small amounts of nitrogen and hydrogen impurities are adsorbed. Before the helium can become contaminated, it is piped directly into shipping containers which have been washed, dried, evacuated and purged.

The helium-analysis apparatus formerly used for control purposes is unable to detect any impurity in the final product. Until a better method of analysis can be found, helium-shielded welds of pure aluminum test strips are made periodically. If a perfect weld is obtained, the helium is shipped; if there is a shadow of a doubt regarding impurity, the helium is repurified.

Most of the refrigeration for the helium production process is obtained from the expansion of natural gas in the crude helium cycle. A separate nitrogen cycle is utilized to supply the additional refrigeration needed to sustain the process. In this cycle, nitrogen is compressed in direct-connected gas-engine-driven compressors in three stages to 600 pounds per square inch. It is cooled in heat exchange equipment, and most of it is expanded in a vertical expansion engine to near atmospheric pressure. The cold exhaust vapors from the engine are directed through tubes in a vessel called a nitrogen liquefier. In the shell side of this vessel, the relatively small volume of nitrogen that was not expanded is liquefied at its initial pressure of 600 pounds per square inch. Liquid nitrogen from the shell side of the nitrogen liquefier is added to the shell side of the helium purifier and to the annular space surrounding the activated charcoal as required.

After passing through the tubes in the nitrogen liquefier, the cold nitrogen exhaust from the expansion engine is directed downward through tubes in the crude-helium separator to provide a little rectification of the crude helium and to add needed refrigeration to that cycle. It then passes back through the nitrogen heat exchanger to a gas holder which is connected to the suction of the nitrogen compressors.

Nitrogen vapors from the shells of the purifiers commingle with exhaust vapors from the expansion engine just before they enter the tubes of the nitrogen liquefier. Nitrogen produced in the helium purifier pot is more than enough to compensate for leakage in the system.

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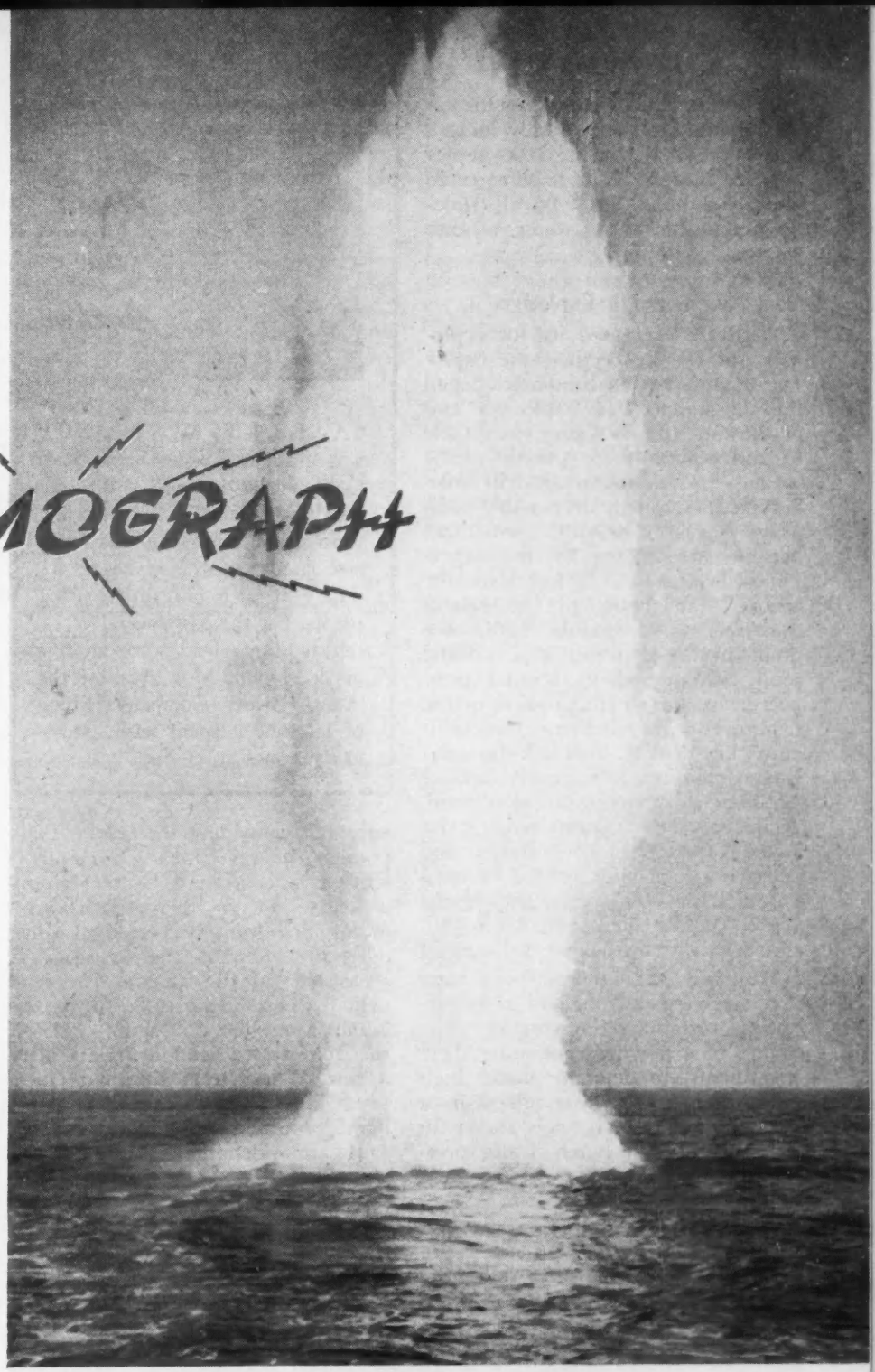
[1] Wheeler, Henry P., Jr., and Swenarton, Louise B., Helium: Bibliography of Technical and Scientific Literature from Its Discovery (1868) to January 1, 1947. Bull. 484, Bureau of Mines (in press).

Explosives for SEISMOGRAPH Prospecting



By LAWRENCE W. BRANIFF
Atlas Powder Company

EXPLOSIVES CONSUMED for seismic exploration currently represent about 7 percent of all commercial high explosives made in the U. S. Manufacturers have developed explosives and blasting supplies that are well adaptable to or especially for seismic exploration. Selection of proper grades of powder for varying conditions may afford economies, and proper loading of shot holes is important. Improvements have been made in electric blasting caps for seismograph work. Important from the safety angle are electric blasting caps with increased resistance to detonation by friction or impact, as compared with detonators formerly used. Other safety features recently introduced have been improved resistance to extraneous electricity and increased water resistance.

ABOUT 100 years ago, Mallet measured the velocity of a shock wave through the sands along the Irish coast. This was probably the first recorded use of explosives for creating a shock wave in the earth to measure its velocity. During World War I, the Germans employed seismographs to locate the position of Allied artillery pieces. It has been only during the past 25 years that the seismograph has teamed up with the use of large quantities of explosives for seismic exploration for oil.

The quantity of explosives consumed for seismic exploration has increased rapidly. Today, it represents approximately 7 percent of all commercial high explosives manufactured in the U. S.

When the first seismic parties entered the field, they were obliged to accept the grades of commercial explosives and blasting supplies then available. As these crews quite often detonated the explosive charge on the earth's surface or at most in shallow, hand-drilled holes, practically any type of detonating explosive produced a satisfactory energy return. Later, it developed that better records could be obtained with the use of smaller explosive charges by

drilling deeper shot points. As the explosive charges were usually located below the water table, the superimposed water and drilling mud pressure limited the type of explosive applicable to the water-resistant gelatin dynamites.

Seismograph Explosives

With the increased use of explosives for oil prospecting, the explosive manufacturing companies began the development of explosives and of blasting supplies more adaptable to and especially for seismic exploration. It was found as drill holes became increasingly deeper that ordinary gelatin dynamites sometimes became desensitized by the superimposed pressure. It has been the theory that the failure of gelatin dynamite to propagate under the great heads of water and drilling mud encountered in seismic prospecting is due to compression of the explosives. To overcome this difficulty, low density, high velocity gelatins containing a relatively incompressible substance were developed. A few of these materials are balsa wood, cane pitch, corn flakes, and corn cobs. An additional advantage is something obtained by impregnating or coating such ingredients with resins or water insoluble substances.

Hundreds of materials have been and are being investigated as propagation sustaining ingredients. The ability of a powder containing these ingredients, to detonate under high water pressures is determined in a pressure bomb such as is shown in Figure 1. In the bomb, water pressures of any amount up to 500 pounds per square inch or the equivalent of a column of water having a height up to 1000 feet may be maintained for any period of time. The efficiency of the explosive is measured by the amount the lead cylinders are compressed when the bomb is detonated. Figure 2 shows the compressed lead cylinders after a test. These tests are made in a steel lined, thick walled, concrete bomb proof shown in Figure 3.

It cannot definitely be stated under what pressure any given seismograph explosive will fail nor how long it can withstand a given pressure and still fire. High velocity gelatins, if detonated immediately after loading, should withstand all water pressures encountered in ordinary prospecting. If the charges are not detonated as loaded, but are allowed to sleep for any length of time, the chance of powder failure increases both as the water pressure and sleeping time increases. The high velocity gelatins are recommended for charges that are not detonated immediately.

Since all seismograph crews are interested in cost savings, there are also available less expensive grades of powder for locations where water conditions will permit their use. A 40 percent strength high velocity gelatin has been developed to replace a 60 percent strength gelatin for areas where water pressures are not extreme, and sleepers are left for only short periods of time. A 60 percent ammonia seismograph gelatin is recommended for water heads of less than 100 feet but not recommended for sleeper charges. The semi-gelatin seismograph dynamite is recommended only for dry holes.

The various explosives available for seismograph work are reviewed in Table 1.

The recently developed 40 percent high velocity gelatin is comparable in cost to ammonia gelatin, and crews using ammonia gelatins should find the 40 percent high velocity explosive a superior product with respect to withstanding moderate water conditions.

Crews should use the cheapest grades of powder consistent with the condition of use. If partial detonations or complete failures are experienced, crews should proceed to grades more suitable to the conditions being encountered.

Besides the failures due to the application of the explosive beyond its physical limits to detonate, some failures, of course, are due to improper loading. In this respect, it is usually advisable to use the largest possible diameter of powder. The larger the diameter of the powder column, the greater are its chances of sustaining propagation, the greater the velocity of the shock wave and the greater the concentration of explosive in the borehole. The necessity of having the cartridges of the explosive butting against one another and of having the charge in one continuous column cannot be stressed too strongly. Although gelatins will propagate from one cartridge

About the Author

LAWRENCE W. BRANIFF was graduated from Iowa State College in 1933 with a B.S. degree in chemical engineering. Since that time, he has been associated with the explosives industry at various manufacturing plants. For the past several years, he has been a field representative in the Joplin, Mo., area for the Atlas Powder Company. Much of his time is spent with seismograph crews in the Southwest.

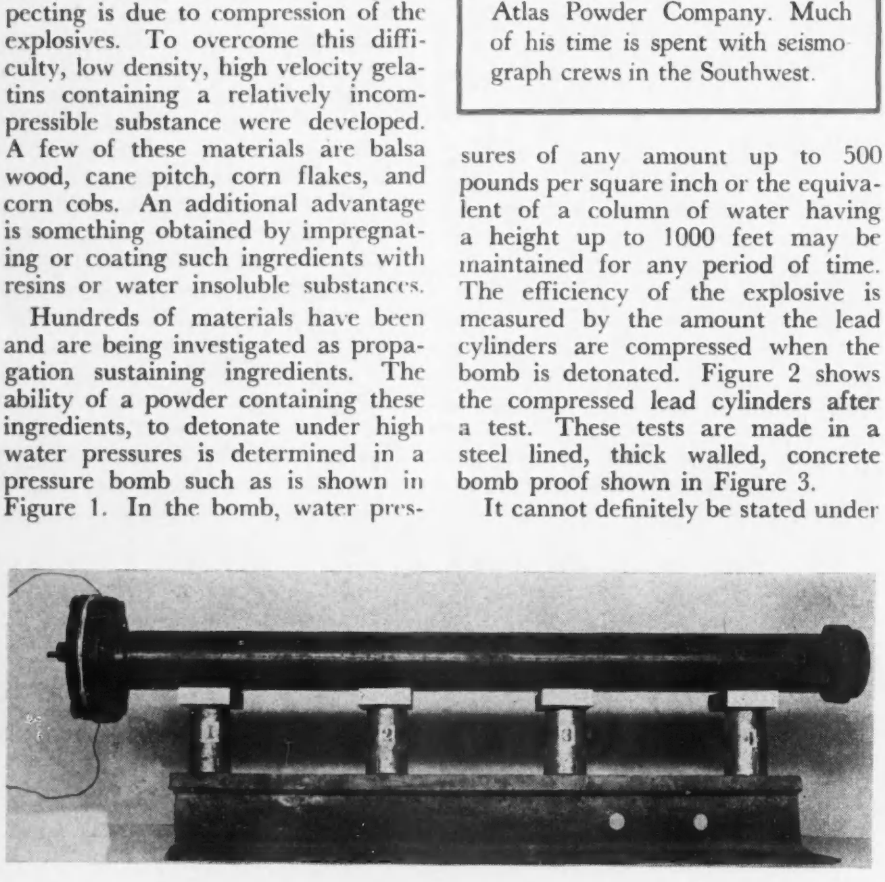


FIGURE 1. Pressure bomb apparatus used to test the efficiency at which a seismograph explosive will detonate under high heads of water.

TABLE 1

NAME	Volume Strength	Unconfined Velocity of Detonation (Feet per Second)	Recommended For
High Velocity Gelatin.....	60 Percent	15,000	High heads of water and sleepers.
High Velocity Gelatin.....	40 Percent	14,000	Moderate heads of water and moderate sleepers.
Ammonia Gelatin.....	60 Percent	15,000	Low heads of water not for sleepers.
Semi-Gelatin.....	55 Percent	14,000	Dry holes—not for sleepers.

to another through an air gap of a foot or two, the propagating distance is greatly reduced if the gap between the cartridges is filled with drilling mud, sand or rock. For this reason, the practice of dropping charges down the borehole in increments is not recommended.

The explosive column may be primed with an electric blasting cap either at the bottom or top of the charge. The electric blasting cap should always be pointed in the direction of the main explosive column and should be well embedded in the gelatin. A powder punch only slightly larger in diameter than the cap should be used. The bottom priming method has the advantage of easier loading and by using several half hitches on the explosive cartridge the possibility of the charge becoming separated is eliminated. The advocates of top priming believe that the shock wave should proceed down the hole for best results and also believe that top priming helps eliminate the hazard of having unexploded dynamite blown out of the bore hole.

Care should be exercised in loading shot holes that have been previously used for a recording. Hot holes should be cooled with water at least until the generation of steam has ceased.

Some crews have felt concern over the fumes emitted at times from the bore hole. An explosive that has an excessive moisture content because of exposure to unfavorable storage conditions or to water in a bore hole will produce upon detonation a greater percentage of objectionable fumes than the same weight of explosive with normal moisture content detonated in a dry bore hole. A burning explosive does no work and gives off a high percentage of poisonous fumes. As seismograph prospecting is conducted in the open, the danger from poisonous fumes is greatly diminished and usually consists of slight nausea or headache to the person inhaling the fumes emitting from the hole. The poisonous gases consist of oxides of nitrogen and carbon monoxide.

Cattle are sometimes reported sickened by water contaminated by the products of complete detonation of seismograph explosives. At one explosives company laboratory, explosives are continually detonated, and the ground therefore contains large quantities of the solid products of dynamite explosions. After a rain, water collects in pools which then contain large amounts of this explosive residue. It has been observed that deer prefer this "salty" water and drink large quantities of it without suffering any apparent ill effects.

However, cattle do like the taste of nitroglycerin explosives, the consumption of which may be harmful to them. All empty containers and lining papers should be burned and unused powder returned to the storage magazine.

Electric Blasting Caps

Considerable improvement has been made in the electric blasting caps available for seismograph purposes. Among the developments most important from the safety angle are electric blasting caps possessing increased resistance to detonation by friction or impact as compared with detonators formerly used. Other safety features recently introduced have been improved resistance to extraneous electricity and increased water resistance.

Much has been written on the detonation of electric blasting caps by extraneous electricity, and at present it constitutes one of the greatest single dangers of personal injury. The hazards due to stray currents and static electricity should be kept to a minimum. The power on nearby electrical equipment should be shut off. Firing cables should be kept in good condition. The cap leg wires should remain shunted until final connections are to be made. A new type galvanometer is now available to detect stray currents in the leading wire. This test is advisable before connecting onto the cap leg wires. Loading should not be carried on in electric storms or dust storms. Alumi-

▪ CONTINUED ON PAGE 90

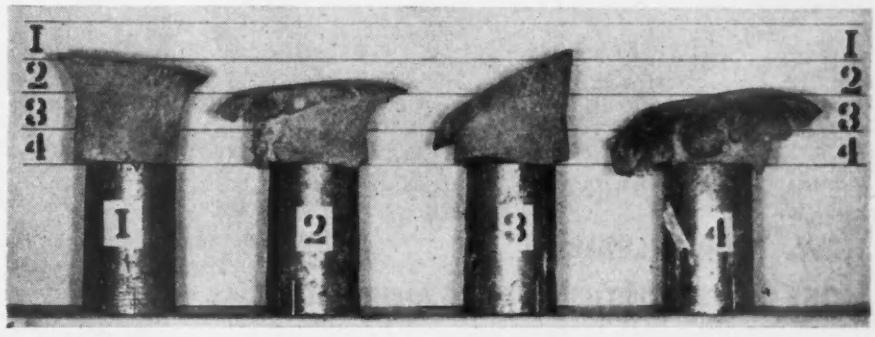


FIGURE 2. Compressed lead cylinders after the bomb has been detonated.

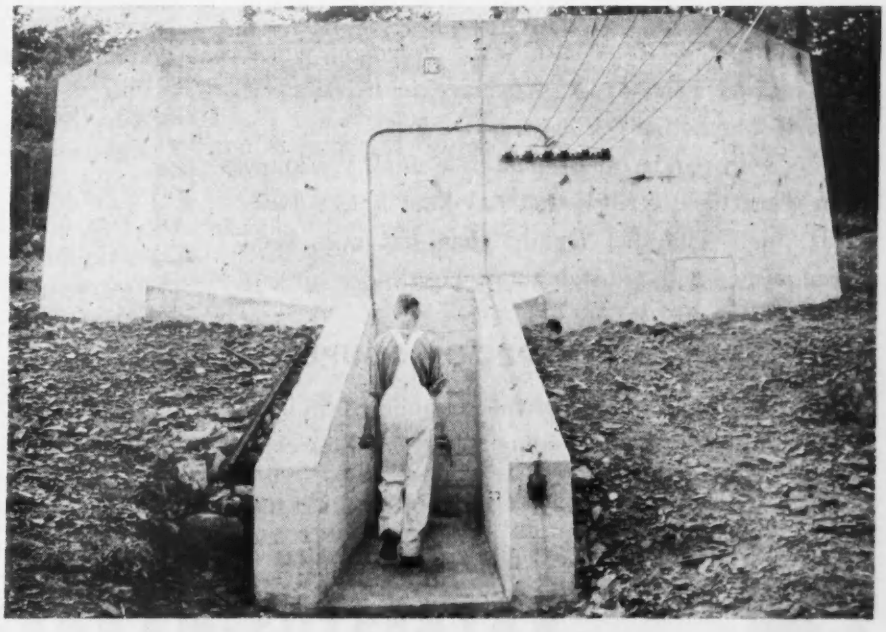


FIGURE 3. A 'bomb-proof' where bombs containing the explosive under pressure are detonated electrically.

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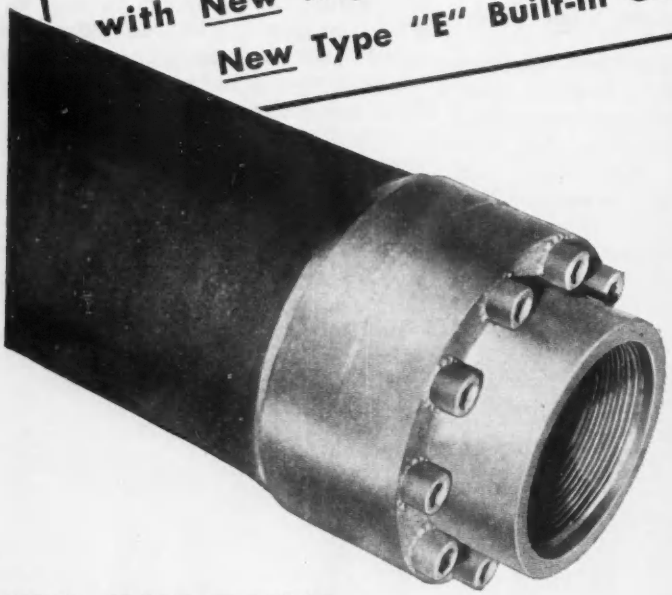

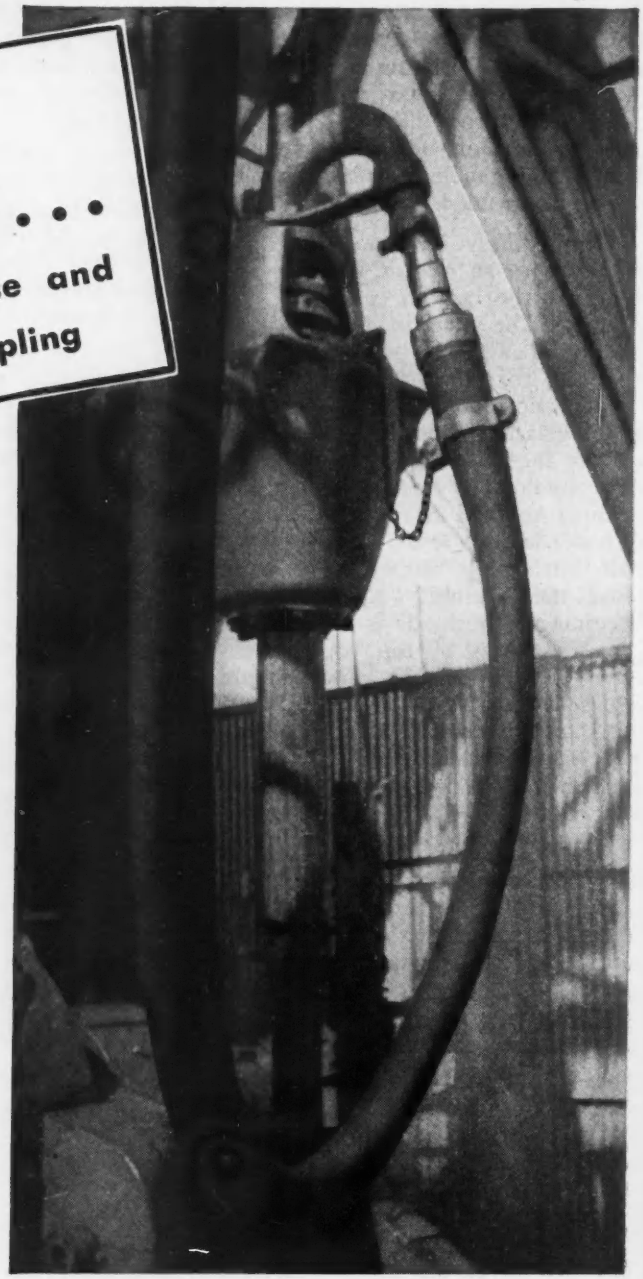

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Ringwood

Proves Major Oklahoma Strike

By HARRY E. LILLIBRIDGE
Mazda Oil Corporation

THE RINGWOOD POOL, Major County, Oklahoma, is one of the more important and least publicized discoveries in the state. It is considered a forerunner of similar strikes where a stratigraphic trap exists along the north rim of the huge Anadarko Basin. Some geologists believe production is found in a reef-detrital or even a reef, and if this proves to be the case it will be the first such production in Oklahoma.

RINGWOOD field, located in Twps. 21 and 22 n., Rges. 10 and 11 w., Major County, Oklahoma, was discovered by The Superior Oil Company of California as the result of geophysical exploration. The discovery well, Manning 1, NE NE NW 27-22n-10w. was completed in 1945 to open the first pool in Major County, Oklahoma. At present there are 80 producers in the field proper, and 3 outpost producers, with the boundaries still undefined.

Block Assembled

During 1943 and 1944 a heavy geophysical exploratory program was under way in northwestern Oklahoma. Among the major companies interested was Superior. Following an intensive survey by Superior, blocking was begun, one of the blocks assembled being the Ringwood block, where it was reported that Superior had shot a high centered around 27-22n-10w., southwest of the town of Ringwood. In 1945 Superior commenced Manning 1, NE NE NW 27. This well was drilled tight and very little information leaked out. It was ascertained, however, during drilling operations that Superior had a show in a Lower Pennsylvanian formation which was variously reported to be Prue, Skinner, Bartlesville and even Mississippian. Eventually the pay zone was designated as the "Manning sand," which was described as fine, brown, hard and tight. Drilling was carried ahead to the Wilcox to 8274 feet, total depth. Manning 1 was then plugged back to 6741 feet. Pipe was set and the formation carrying a show from 6705-35 feet was shot with 90 quarts. The well flowed 43 barrels oil in 24 hours through 40/64-inch choke. The zone was re-shot with 200 quarts and the well then made 35 barrels of 41 gravity oil per day with 350,000 cubic feet of gas through 40/64-inch choke, casing pressure 200 pounds and tubing pressure 40 pounds. The well was completed in late 1945.

With information mostly rumor and production light, development was very slow. Julius C. Livingston of Tulsa, teamed in 1947 with Harry Blackstock and D. G. Rowland of Oklahoma City to drill Mazda, Blackstock and Rowland's Hays 1, SE SE SW 22-22n-10w, a north offset to the discovery. Their Hays 1 had considerable gas but little oil. Superior drilled four additional wells on nearby acreage but none proved a good producer. In 1948 Mazda, Blackstock and Rowland drilled their Wight 1, NE NW SW 27-22n-10w for the first good production from the Manning, the well being completed for 238 barrels.

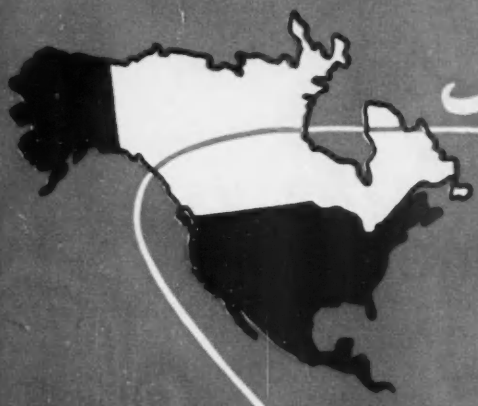
Others became interested in the area, and at present there are 12 companies or individuals owning producing properties in the field. Superior and Mazda have led development. The first wells, we now know, were located well toward the northern limit of production. Good production has been found to the southward, with the field now extending eight miles east and west and seven miles north and south. During February and March, 1950, Superior drilled Adkins 23-23 in 21n-10w and Fuller 63-30 in 21n-10w. These wells, however, are considered wildcats and not in the field proper. Fuller 1 is on pump, while pipe was not run in Adkins 1.

Drilling Procedure

During the earlier stages of development in Ringwood field it was considered better practice to cut rotary hole to the top of the Manning, set casing, and drill in with cable tools. Operators now drill through the Manning section and into the shale below before running casing.

The majority of Ringwood operators set 300 to 350 feet of 10- or 10¾-inch surface pipe. Size of hole cut varies from 8¾ to 9⅝ inches with 5½- and 7-inch casing, respectively, being run. Mazda and Superior, the major operators in the field, cut 9-inch hole and run 7-inch casing. C. Andrade III of Dallas, Texas, cut 8¾-inch hole and set a 5½-inch string. The casing string is usually cemented with 400 to 600 sacks.

Maintenance of a good drilling mud has proved very difficult. The mud is heavily contaminated with salt from the anhydrite series, found at approximately 1600-2350 feet, and additional salt content is noted after the Layton series is penetrated. The average well is mudded up lightly from 3000-6000 feet. Below 6000 feet the wells are mudded up, and an attempt is made to maintain a good drilling mud at all times until casing is run. Between 6200 feet and the base of the Manning it is desirable to



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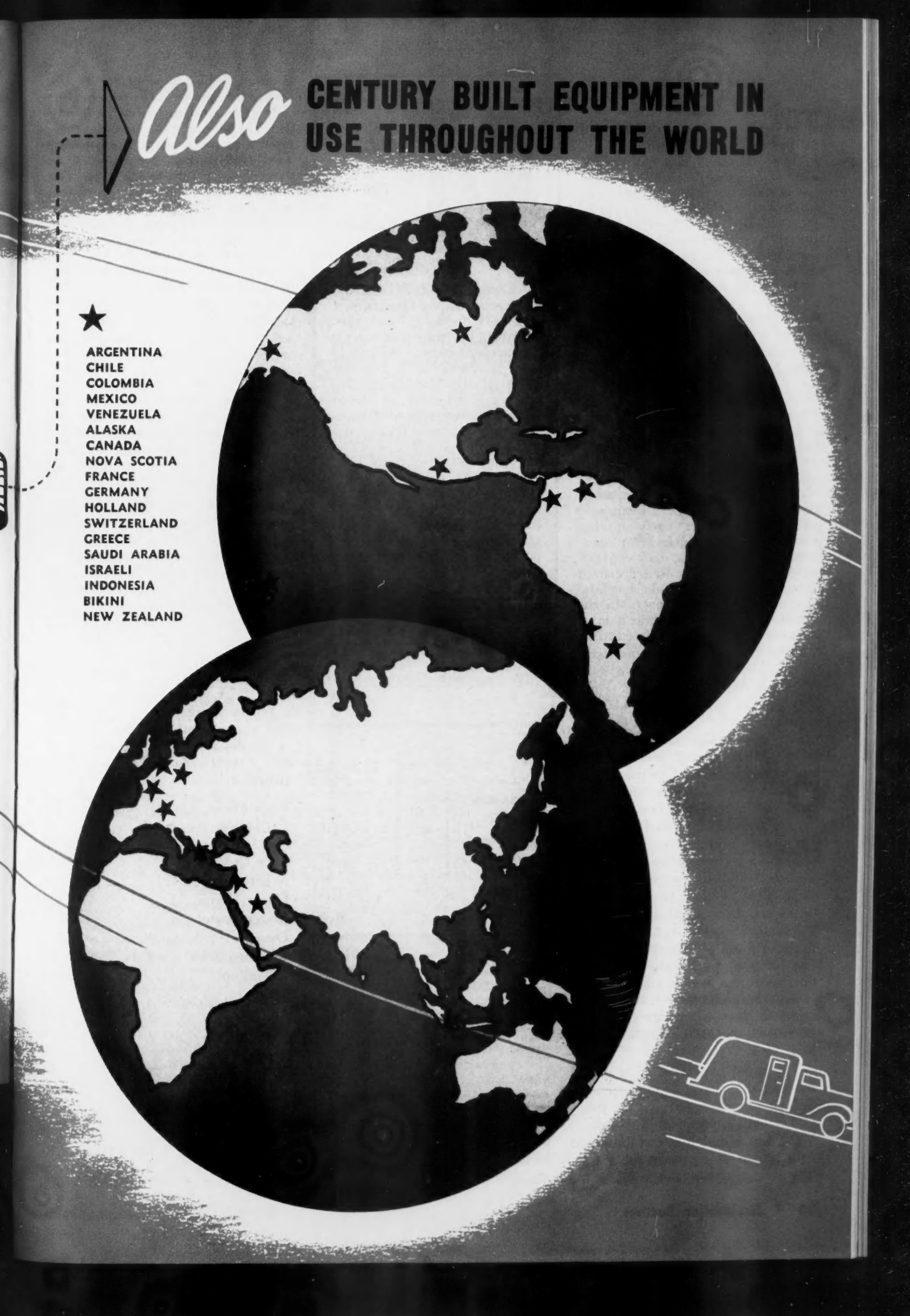


keep the viscosity between 45 and 50 with the weight below 9.8 pounds. Generally a salt water starch preserved mud is used. Average mud cost per well over the field is $3500.

A few operators run electric log prior to running casing, and a few run electric log before setting pipe and also radioactivity log afterwards. But the great majority run casing and then run radioactivity log in order to pick the exact perforating points. Perforations average 4-6 shots per foot. The well are then acidized with from 15,000 to 30,000 gallons and flushed with a 100 to 400 barrel oil load.

Average cost per well completed would be approximately $75,000.

Development

Spacing is designated on the basis of one well per 40 acres. The present daily allowable is 140 barrels per day.

Until recently the lease ownership in the field proper was approximately as follows: Superior 75 percent, Mazda 20 percent and all others 5 percent. At present, however, Superior has completed farmout negotiations on 20 spreads, each containing 400 to 440 acres, well dispersed through the field. Mazda has also acquired additional acreage. In the fall of 1949 Superior made a large farmout to C. Andrade III of Dallas. Andrade has 19 completed producers on this property and has completed all of his drilling obligations. Until May 1, operators in the field were Mazda, Superior, Andrade, The Atlantic Refining Company, Champlin Refining Company, Producers, Tide Water Associated Oil Company, J. E. Trigg, and Stephens Petroleum Company. The recent Superior farmouts call for immediate or early development, and during recent weeks new operators who had already begun operations included: Coronado, Deardorff, Bolsa Chica, Great Western Producers, Geo. P. Livermore, Inc., Wilco, Beatty-Humphrey, R. M. Burke, Harold C. Morton, Exploration Oil and Gas Company, J. M. Burkhardt and J. H. Caraway. Some of the others who have taken spreads and will move in shortly include J. W. Sorrells and Harbar Drilling Company et al.

The rapid expansion of this field has been due largely to the aggressive drilling campaign directed by Julius C. Livingston, president of Mazda.

Oil accumulation in the Ringwood field is due to a stratigraphic trap. The producing zone in the field is the Manning, which pinches out to the northward, and with the present producing limit ranging from 22 to 147 feet. The Manning thickness increases rapidly to the south and southwest. Two cross-sections are included to show the structure in the area. The NE-SW radioactivity log cross section across the field indicates the south dip of the area and also the thickening of the producing horizon to the south and southwest. The NW-SE cross section, constructed parallel to the strike of formation shows the lack of any appreciable thickening or thinning to the east and west. It also indicates absence of folding in the area.

Near Boundary

Due to the thinness of the Manning to the north, it is doubted that the northern limit of production will extend much beyond the present boundary.

On the accompanying Manning map it will be noted that the highest subsea contour at which production is had is —5400 feet, while the lowest contour level is —5550 for the field proper. However, to the south and down dip, Mazda has two producers, and still further down dip Superior has one producer. It is safe to assume that the limits of production will extend considerably beyond the —5550 contour level or limit. There is no water drive in the field.

Formation markers typical of the area are found in Superior's Manning 1, the discovery well, located in NE NE NW 27-22n-10w. Elevation is 1276 feet.

Wellington	1260
Herrington	2385
Florence	2650
Deer Creek	3920
Avant-Dewey	4920
Upper Layton Sd	5300
Lower Layton Sd	5720
Oswego	6275
Manning Zone	6705-6734
Mississippi	6985
Wdfd	7634
Hunton	7693
Sylvan	7723
Viola	7820
Simpson dense	7883
1st Wilcox	absent
2nd Wilcox	8113
T. D. in green shale	8274

The Manning is not a sand, as its name implies, but a zone composed

■ CONTINUED ON PAGE 90

About the Author

HARRY E. LILLIBRIDGE was graduated from the University of Oklahoma in 1922, and then served as field geologist for the Oklahoma Geological Survey. In 1925 he worked as a scout for ITIO in the Cushing district, Oklahoma, and two years later he was transferred to Enid, Okla., as geologist, and later became district geologist. When ITIO merged with Cities Service Oil Company he joined Eason Oil Company. He resigned in 1941 to become a consulting geologist. For the past two years he has been associated with Mazda Oil Corporation as consulting geologist, with headquarters at Enid.

STATISTICAL DATA ON DRILLING OPERATIONS AND COMPLETIONS
(as of July 1, 1950.)

Operator	Wells Drlg.	Wells Completing	Wells Completed
Mazda	8	3	29
Superior	1	0	23
Andrade	0	0	20
Atlantic	0	0	2
J. E. Trigg	0	0	2
Producers	0	0	1
Stephens	0	0	1
Morton	2	0	0
Burke	2	0	0
Bolsa Chica	2	1	1
Tidewater	1	0	1
Beatty-Humphrey	2	1	0
Coronado	0	1	0
Great Western	1	1	0
Wilco	1	0	0
Livermore, Inc.	2	0	0
Exploration	1	0	0
Deardorff	1	0	0
Burkhardt	1	0	0
Caraway	1	0	0
Total	26	7	80

Contractors (Rotary)	No. Rigs
Warren-Bradshaw	5
Loffland Bros.	5
Harbar Drlg. Co.	4
Vierson-Cochrane	2
L. B. Jackson	2
Mid. Union	1
Nelson	1
Superior	1
Zephyr	1
Deardorff	1
Brown	1
Manning	1
Wilco	1
Total	26

Contractor (cable tool)	No. Drlg. In Units
Tract Service Co.	3
Percy Jones	1
Wire Line Service Co.	1
Livermore, Inc.	1
Oil Well Service Co.	1
Total	7

Lithologic Criteria of ARBUCKLE IN WESTERN KANSAS

By JOSEPH R. CLAIR
Denver Sample Log Company, Denver
and
FANNY CARTER EDSON
Geological Consultant, Chillicothe, Ill.

THE ARBUCKLE is a most important producing section in Kansas, and drilling and exploration trends in Western Kansas and adjoining states make it imperative that its characteristics be easily recognized. This important section and its component subdivisions can be identified on the basis of lithology, detailed sample work has shown. As an aid to geologists in correct correlation, this article presents some lithologic criteria for identification and subdivision of the section.

A FEW of the deeper wells in far western Kansas and adjoining states have penetrated completely the beds referred to as the Arbuckle group and have reached Pre - Cambrian rocks. Examination of samples from these wells indicated that the Pre-Chazyan, Post Pre-Cambrian beds could be subdivided into units solely on the basis of lithology, which could be recognized over the entire area and correlated from well to well.

Names of formations exposed at the surface in the Ozark Mountains were originally applied to these units by the writers, not because their exact equivalency was established, but because each subsurface unit had some characteristics similar to those of the surface formation from which it is named.

Subsequently, the writers, in order to facilitate usage of the criteria, decided to use zones rather than named units. The writers wish to point out that these zones, as outlined herein, have no direct correlation to subsurface units or zones based on insoluble residue studies. It is the writers' feeling, however, that the average sample worker has neither the time nor facilities for insoluble residue work and yet needs to have some criteria for identifying the age of the Arbuckle rocks he encounters.

The writers have worked independently on this problem and the findings set forth below are a combination of the criteria developed by both.

Ordovician System

Beds of Beekmantown Age

Beds of Beekmantown age recognized in this area are referred to as Zone 1 and Zone 2, Subzones A, B and C.

Two wells have encountered rocks which may correlate with the uppermost Beekmantown beds of the Ozark type section and these are here included under Zone 1.

Where the complete sequence of Beekmantown beds has been penetrated in one well in the area, the thickness of this sequence is 340 feet.

The uppermost rocks of Pre-Chazyan age encountered in the area of this paper are difficult to assign to any definite unit. In lithologic appearance they most closely resemble the uppermost beds of the Ozark type area. However, since they have been penetrated in only a few wells, the writers have chosen to classify these under Zone 1 until more information is available.

This unit is characterized by buff, grayish buff or tan, finely crystalline to crystalline dolomite, becoming more light brown and brown, and more coarsely crystalline and porous toward the base. Beds of saccharoidal or finely rhombic dolomite with interstitial tripolii are sometimes present. Chert is sparsely present and when present is generally found in the upper part. The chert observed is white, light gray, blue-gray or tan, hackly, sometimes vitreous, often waxy, semi-opaque to opaque, occasionally tripolitic. Porosity is vuggy in character and large secondary dolomite crystals and pseudomorphic selentite crystals are abundant in the lower part. Light turquoise green shale partings are common and some of the beds of dolomite, particularly in the lower part, are sandy. The sand, however, is much finer and in far smaller quantity than that found in the underlying beds. None of the samples of wells in Kansas examined by the writers penetrated beds as young as the sequence just discussed.

Location of Rocks

Rocks assigned to this unit by the writers are present in The Pure Oil Company Cox 1, 16-5n-8ecm, Cimarron County, Oklahoma 5509-5645; and Skelly Oil Company Hankins 1, 34-33S-44w, Baca County, Colorado 6075-6155.

The thickest observed development of this zone is 136 feet.

ZONE 2: A regional unconformity marks the top of this zone and truncated beds assigned to this unit are found in several wells in southwestern Kansas and the adjoining parts of Colorado, Oklahoma, and northwestern Texas.

SUBZONE "A": The subsurface rocks assigned to this unit are characterized by buff, tan, pink or various shades of brown, crystalline to very coarsely crystalline dolomite, which is generally granular or saccharoidal, but may be finely rhombic or oolitic. Chert is much more common than in the overlying Zone 1. The cherts are white to brown in color, may be translucent or opaque, often are very finely oolitic and generally vitreous.

Some very small translucent oolitics both free and imbedded have been observed. This subzone contains more sand than the overlying beds and particularly toward the base may be quite sandy. The sand is medium to coarse, frosted and rounded, and may be embedded in the dolomite or found as free grains and aggregates. This subzone is 105 feet thick in its fullest subsurface occurrence observed by the writers.

SYSTEM	EPOCH or AGE	ZONE	SUB-ZONE	SECTION	THICKNESS	CHARACTERISTICS ROCK, COLOR, CRITERA, ETC.
ORDOVICIAN	BEEKMANTOWN	ZONE I			80'-136'	Dolomite, buff, gray, tan, saccharoidal, chert sparse vuggy porosity, large secondary xls dolo & selenite, slighty sandy.
						REGIONAL UNCONFORMITY
		ZONE II	A		50' -105'	Dolomite, buff, tan, pink or shades of brown - xln to coarsely xln - granular or saccharoidal chert more common than above white to brown trans or opaque, often finely oolitic contains considerable sand, particulary toward base
			B		50'-246'	Dolomite, gray, buff, brown, xln to c. xln rhombic to coarsely saccharoidal - chert most dominant characteristic - are coarse semi tr. to opaque with dark gray, brown or tan oolites, oolites darker than those containing matrix white "cotton" cherts, wh. or lt. gray, vitreous sdy cherts, coarse oolitic & oolicastic dolomite. Lenses & beds of sand common. sand most generally embedded in dolo or chert. glauconite present but sparce
			C		0'-170'	Dolomite & sand, grayish - buff cream to brown - finely saccharoidal granular or medium xln - abrupt increase in sand percentage. - definite change in oolitic cherts, sand coarser than above - more aggregated sand - much finely oolicastic dolomite which is generally saccharoidal - green glauconitic shale in upper part - oolites in chert same color as matrix (shadow oolites) Trash zone at base
						MAJOR REGIONAL UNCONFORMITY
CAMBRIAN	ST. CROIXIAN	ZONE III	A		100'-315'	Dolomite, gray, white, cream, light buff - coarsely rhombic, tripolitic - sparsely cherty in upper part - olive green shale or turquoise green shale laminae - lower 50' quite cherty - cherts milky white gray or buff - sometimes finely oolitic or are dolomite or sandy - glauconite sparse generally found most at top - quite sandy toward base.
						REGIONAL UNCONFORMITY
			B		40'-65'	Dolomite, buff, gray or brown - coarsely xln - frequently glauconitic - sparcely cherty - buff to white oolitic chert or cream white dolomitic chert - bright green laminae in top part - pyritic at base
			C		35'-90'	Dolomite, buff, pinkish buff brown - coarsely saccharoidal very coarse xln or very rhombic white vit. coarsely oolitic chert in Oklahoma & Texas. white & buff gfzose & dolomitic chert in Kansas. sand dolomite at base
						REGIONAL UNCONFORMITY
		ZONE IV			50'-120'	Dolomite, gray, buff, various shades of brown & red, very coarsely xln rhombic or saccharoidal - concentration of glauconite most diagnostic - always sandy - increases in percent toward base - devoid of chert

Generalized stratigraphic section of Arbuckle rocks.

ZONE 2, SUBZONE "B": Beds assigned to this subzone are the top members of the Arbuckle sequence over a large part of the area of western Kansas, from the Central Kansas Uplift westward. Because of its position in the section, the beds of this subzone have been severely truncated and their maximum thickness is not known. The maximum observed thickness to date is 246 feet in the Marathon, Kline 1, 19-14s-24w, Trego County, Kansas. The thickness observed with Subzone "A" overlying, is much less than this figure, but these are found far to the southwestward and the Arbuckle is known to be thinning rapidly in this direction.

Character of Zone

The unit is characterized by gray, buff, creamy buff, light brown or brown, crystalline to very coarsely crystalline, very rhombic or coarsely saccharoidal dolomite. The cherts of this subzone are its most dominant characteristic, and they are considerably more abundant than in younger Arbuckle beds. Probably the most characteristic cherts are the coarse, semi-translucent to opaque cherts with dark gray, brown, or tan oolites, with the oolites always darker than the containing matrix. White "cotton" cherts, white and light gray, semi-translucent to opaque vitreous sandy cherts, and brown and tan, semi-translucent vitreous cherts are other common varieties of this sequence.

Thin, dark green, glauconitic and pyritic shale streaks are present in the upper part of the subzone, and olive drab to turquoise green shale laminae are often present in the lower part. Large, white or dark brown, free siliceous oolites are frequently observed. In some wells the dolomite is quite oolicastic (or oocastic), but when this characteristic is observed, the oolicasts are quite coarse, and oolitic dolomite is generally associated. Lenses and beds of sand are common in this subzone, particularly in the lower part, but in general the percentage of sand is much less than that observed in the underlying subzone. The sand is medium to coarse, both clear and frosted, angular to rounded, and is generally found embedded in the dolomite or in chert. In one well, The Texas Company's Seal 1, 9-24s-27w, Gray County, Kansas, an unusual concentration of crystalline sphalerite (zinc sulphide) was encountered in this sequence. Glau-

conite is another mineral frequently observed in this subzone.

ZONE 2, SUBZONE "C": Beds assigned to this subzone form the top of the Arbuckle in many wells in western Kansas, due to the severe truncation of Arbuckle beds. The unit is characterized by grayish-buff, cream, light brown, or brown and buff, finely saccharoidal to granular, finely crystalline to medium crystalline dolomite. An abrupt increase in the percentage of sand in the samples, together with a definite change in the type of oolitic cherts, characterizes this sequence. The sand is coarser than in the overlying Subzone B and is sub-rounded to rounded, frosted and clear; also, more aggregated sand is present indicating distinct sand beds. Much sand is embedded in the dolomites, and much of the oolicastic appearance of some beds is probably due to the jarring out of sand grains in drilling. The cherts of the unit vary from white to gray, or light gray to tan or brown, semi-opaque to translucent, waxy to vitreous, with much of the chert containing sand grains or fine oolites which are nearly the same color as the containing matrix. One of the writers has used the term "shadow oolites" to describe these cherts. The lower part is often quite oolicastic, but it is distinguished from the oolicastic dolomites of the overlying subzone by being much finer in texture and more saccharoidal. Olive drab or green glauconitic shale is generally present in the upper portion, and pale turquoise green shale laminae are often quite common. Disseminated glauconite is frequently found in this unit, particularly along the western part of the state. The lower part is quite pyritic in some wells and the chert is white and often tripolitic. The regional unconformity between the Ordovician and Cambrian systems marks the base of the subzone. A definite "trash zone" marking this unconformity is seldom observed, but enough reworked material is present to leave little doubt of its existence.

Truncation at the top and the unconformity at its base make this subzone one of the most variable units as to thickness in the entire Arbuckle sequence. It varies from 50 to 170 feet in Kansas, and 0 to 50 feet in Oklahoma Panhandle. No data as to its thickness in Colorado are available to the writers.

Sample work has not disclosed additional section which is present in the Ozark area, and the writers have assumed that these rocks were not deposited in the area under discussion.

Cambrian System

Beds of St. Croixian Age

Beds of Upper Cambrian St. Croixian Age are referred to Zone 3, Subzones A, B and C and Zone 4. It is possible that additional work may prove the presence of another subzone between A and B, but information is so meager as yet that the writers believe it wiser to group the rocks as indicated above.

ZONE 3, SUBZONE A: The rocks assigned to this subzone are perhaps the most distinctive of any in the Arbuckle sequence. This unit is characterized by dominantly gray to white or cream, and light buff, coarsely crystalline, coarsely rhombic, and often tripolitic, very porous and vuggy dolomite. The upper portion is sparsely cherty or devoid of chert. Much mineral dolomite in the form of clear rhombic crystals is generally found in the upper 50 to 60 feet. Abundant crystals of sphalerite as well as dolomite are present in this section in Sinclair Oil & Gas Company's Glad & Brock, SE NW NE 19-13s-42w, Wallace County, Kansas. Thin beds of olive-green or turquoise-green shale are interlaminated with the dolomites of this subzone, and in one well National Refining Company's Wells 1, 13-23s-30w, gray, waxy shale was present in considerable amounts in the lower part. The lower 50 feet of the unit is characterized by considerable chert and is often quite sandy, particularly at the base. The cherts are generally milky white, to gray or buff, are sometimes oolitic, translucent to opaque, have minute crystals of mineral dolomite embedded in the chert or are translucent with embedded sand grains. Glauconite is sparsely present throughout the sequence, but if present, is generally most abundant at or near the top of the subzone.

The major regional unconformity marking the top of Zone 3 is responsible for the rather wide variations in thickness encountered. It varies from 100 feet to 315 feet in its thickest development with an average thickness of around 165 feet. In the section of maximum thickness, beds of Subzones B and C may be included in Subzone A, but characteristics of these formations were not observed by the writers in the samples of the Watchhorn Alma & McNeely 1, C SW SW 13-15s-33w, Logan County, Kansas.

As previously mentioned, beds which might well form a separate subzone below Subzone A have not been recognized by the writers in the area of this paper. It has been reported that rocks which would be assignable to this subzone have been found on and along the flanks of the Central Kansas Uplift, but apparently they were not deposited farther to the west.

ZONE 3, SUBZONE B: Beds assignable to this subzone are recognizable in only the extreme western part of Kansas, and southward into the Oklahoma and Texas Panhandles. They were, apparently, either not deposited over the remainder of the area, or their characteristics are so changed that they are not identifiable from the overlying Subzone A by purely lithologic examination.

These formations are characterized by buff to gray or brown, crystalline to coarsely crystalline dolomite. The beds are frequently glauconitic and generally are sparsely cherty. However, buff and white opaque oolitic chert or coarse white opaque dolomitic cherts are observed. Thin laminae of bright green shale and some slightly sandy greenish white saccharoidal, glauconitic and sometimes pyritic dolomite occurs at the base in some wells. It varies in thickness from 40 to 65 feet in wells in which it has been observed.

ZONE 3, SUBZONE C: Like the overlying subzone, rocks assigned to this unit can be differentiated only in far western Kansas and southward into Oklahoma and Texas. The subsurface beds assigned to this unit are characterized by buff or pinkish buff to brown coarsely saccharoidal or coarsely crystalline very rhombic dolomite. In Texas and Oklahoma buff and white vitreous, coarsely oolitic chert characterizes this subzone, but this type of chert has not been observed in the Kansas sections. They apparently change laterally to white and buff quartose and dolomitic cherts which are the dominant cherts found in this unit in Kansas wells in which it has been recognized. Dark green shale laminae are common and glauconite is sparsely developed. A buff to brown saccharoidal dolomite occurs at or near the base of the formation.

Variation in the thickness of Subzone C is apparently attributable to overlap after the erosion interval which followed deposition of the underlying Zone 4. Its thickness varies from 35 to 90 feet where observed.

ZONE 4: The rocks of this zone are present at the base of the Arbuckle in all wells which have penetrated Pre-Cambrian rocks in the area of this paper. The subsurface beds as-

signed this unit have several diagnostic characteristics. The dolomite varies from gray to buff and light brown, to brown, to various shades of reddish-buff or reddish-brown. It is always coarsely crystalline, either saccharoidal or rhombic, and is invariably very glauconitic. In fact the concentration of glauconite is probably its most diagnostic feature. The formation is always more or less sandy and the percentage increases toward the base. The sand is medium to coarse, angular sometimes aggregated and glauconitic, but more often embedded in dolomite. Some free, rounded, coarse grains are generally observed. The reddish color of the dolomites is more often observed in areas close to old positive land masses. Chert is sometimes observed, but it is so sparse that for all practical purposes, this zone is devoid of chert. Probably the occasional chert fragments are cave or recirculated material. Styolitic black shale partings are generally noted in the lower part of the zone, and pyrite is often quite abundant.

The Post-Zone erosion interval was of considerable duration and the observed thicknesses are quite variable. The zone varies from 50 to 120 feet in the area of this paper.

In far western Kansas the Arbuckle group varies from 249 feet with only Cambrian beds present, to a maximum of 645 feet made up of both Ordovician and Cambrian beds. In Oklahoma and Texas the group as a whole thins materially southwestward from a maximum of 758 feet in Pure's Cox 1, 16-5n-8ecm, comprised of both Ordovician and Cambrian, to 380 feet in Pure's Federal Land Bank 1, 17, Block 7, F.W.&D. Survey, Dallam County, Texas, where Cambrian beds make up the entire sequence.

The Arbuckle rests on Basal Cambrian Sandstone (Reagan, Lamotte) in all but one well which has reached the basement rocks in Kansas. In the Oklahoma and Texas portion, no Basal Paleozoic sandstone is present, but a major, regional, angular unconformity marks the base of the Paleozoic sediments everywhere in the Mid-Continent region.

In conclusion, the writers hope that the foregoing criteria may serve as a starting point for present and future workers in the region, and in the end help lead to a better understanding of the Arbuckle group in this vast and, as yet, almost untouched province.

REFERENCE

[1] Earl McCracken, Missouri Geological Survey, Rolla, Mo.; personal communication.

Explosives for Prospecting

■ CONTINUED FROM PAGE 75

num loading poles should not be used.

For areas having highly conductive water, or for off-shore shooting, the use of two caps, having uniform bridge wire resistances, in series is often advisable. As the bridge wire resistance and thus the minimum firing current required to detonate the caps of the various manufacturers differ, it is recommended when using caps in series that all caps be of the same brand.

There has been a worthy tendency for crews to go from the use of a No. 6 electric blasting cap to the higher strength No. 8 detonator and in some cases to a No. 10 or larger cap. For crews considering the use of the stronger caps, it is well to mention that the electrical circuits of all strength caps made by a single manufacturer are similar and that the firing characteristics are comparable. In the various strength caps the base charge is increased for the stronger caps. A No. 8 cap can be used to detonate a charge and a No. 6 cap in series can be used to provide a time break. Some seismograph caps are tested for uniformity in series firing. This uniformity in series firing has its greatest advantage in the Poulter Method of surface shooting where it is desired to detonate several explosive charges simultaneously.

Destroying Explosives

It is sometimes necessary to destroy explosives. Such explosives may be fresh material which has been damaged; usable material for which there is no further need on a job; or material which has deteriorated. The preferred method of destroying dynamite is by burning. Seismograph gelatin dynamites are particularly prone to detonate on burning, so not more than ten pounds should be destroyed in this manner at any one time. If large quantities of explosives must be destroyed, and experienced or competent men are not available for the work, or if there is any question about the safety of the undertaking, then the handling and destruction of the explosives should be deferred until a representative of the U. S. Bureau of Mines or of the explosives manufacturer has been consulted.

To destroy electric blasting caps it is desirable first to cut off the leg wires about one inch above the top of the cap, preferably with a pair of tin snips. Not more than 100 caps should be placed in a box or bag with about one-half pound of dynamite, primed with a good electric blasting cap, buried under sand or dirt, and fired from a safe distance. The ground around the shots should be thoroughly examined to make certain that no unexploded caps remain.

Ringwood Pool

■ CONTINUED FROM PAGE 80

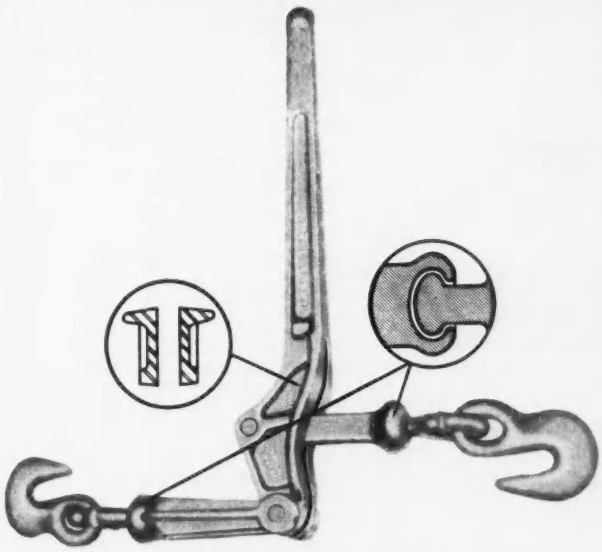
principally of lime. The lime component is usually dense, oolitic and sometimes fossiliferous. However, in many instances it is dolomitic and non-oolitic. Much dolomite, sandy-dolomite and sand also occur in the Manning. The wells to the north side of the field, where the section is thinner, appear to have a much higher percentage of sand. When present in the Manning sand as an average constitutes a very small percentage of the formation. Due to the lime reservoir, drill-stem tests have not been too successful in the field, for little free oil is noted prior to acid treatment. In a very few instances where the Manning has had a considerable percentage of porous dolomite, or sandy-dolomite or sand, the wells have had oil in the hole or have flowed following perforating. Acidizing must be relied upon for production in the field, for the wells will not produce without heavy treatment. The Manning zone varies from an unbroken pay section to one with numerous thin shale breaks. In some instances thick shale breaks have been noted. The heaviest production has been obtained to date in the east central part of the field and notably in 35-22n-10w and 2-21n-10w.

To date there are no dry holes within the field boundary, and there are no wells on the pump. All wells were completed as flowing wells and have remained so.

Future Possibilities

As of July 1, 7040 acres could be regarded as proved. Due to the type of structure causing the oil accumulation, the production is regarded as likely to cover an extensive area. It is the writer's opinion that close to 30,000 acres will become productive.

The writer also believes that the Ringwood field will prove to be the forerunner of many such fields where a stratigraphic trap exists along the north rim of the Anadarko Basin in northwestern Oklahoma.



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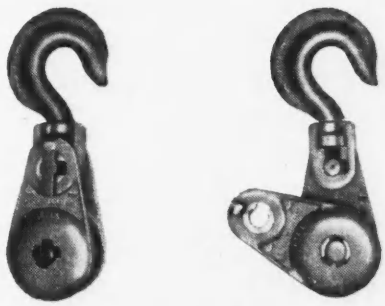

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LeBus "Bulldog" Load Binders are 100% proof tested for load capacities of 10,000 lbs. to 40,000 lbs. at the factory. Made of alloy and high carbon steel, the "Bulldog" Binder is machine fitted and heat-treated after forging for strength and durability. Handle and linkage gives maximum leverage—clevices and hooks will not deform or bind in roughest service. Fully Guaranteed.

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The LeBus "All-Purpose" and Gin Pole Block may be readily adapted for all purposes through its complete interchangeability of parts. Completely assembled or disassembled by hand (no tools needed), the LeBus "All-Purpose" block gives SAFETY with SPEED in operation. THE FINEST IN THE WORLD!

LEBUS TAIL CHAINS

LeBus Tail Chain links and hook are drop-forged, heat-treated steel which will withstand the roughest treatment. Guaranteed to the proof test specified, LeBus Tail Chains will stretch before breaking but will not freeze. Available in lengths from 12" through 24", sizes ⅜" through ⅞", proof tested from 7500 lbs. through 75,000 lbs.

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Used to connect hooks to load binders, chains and cables. Drop-forged from high grade steel and heat treated to increase its ultimate strength. Available in sizes from ⅜" to ¾".

SINGLE CHAIN HOOK

Drop forged, high grade, heat-treated steel hooks. Sizes from ¼" to ¾" and proof tested from 16,000 to 40,000 lbs.

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Primarily used to connect two chains. A valuable piece of equipment in general work around the truck and yard. Drop forged high grade, heat-treated steel. Sizes to fit from ¼" through ¾" chain—proof tested from 16,000 to 40,000 lbs.

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Exploration

Leads 1949 Period 16 Percent

A RECORD 849 exploratory wells were completed in October to boost the year's ten-month total into a lead of 16 percent over those drilled in the comparable period of 1949. The month's activity resulted in 167 tests being completed successfully as producers, and although that total was not a new mark, it was the second highest number of exploratory producers completed in a single month.

The month's exploration added 112 oil pools to the nation's total. New oil fields totaling 84, and 28 new oil pays in established fields made up the new oil discoveries. New distillate sources totaled nine and they were comprised of six new fields and three new pay strata. Natural gas discoveries numbered 14 and all expect one of these were new fields.

In the first ten months of this year exploratory wells completed totaled 7160 to top the 6167 drilled in the same period of last year by 16.1 percent. Commercial producers resulting from those tests did not maintain quite as good a ratio as last year's wells, although they were more numerous. This year's 1393 successful ventures amounted to 19.5 percent of the total drilled, while a year before the score had been 20.7 percent successful.

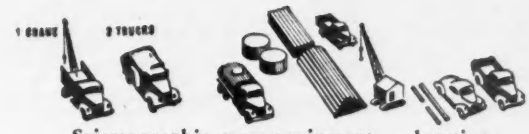
Summary of Results of Exploratory Drilling

ITEM	Oct., 1950	Sept., 1950	TEN MONTHS January-October 1950	1949	Percent Diff.
Oil Discoveries	112	91	915	815	+ 12.3
New Fields	84	70	677	564	+ 20.0
New Pays	28	21	238	251	— 5.2
Distillate Discoveries	9	11	75	109	— 31.2
New Fields	6	8	58	61	— 4.9
New Pays	3	3	17	48	— 64.6
Gas Discoveries	14	16	124	124	
New Fields	13	14	109	103	+ 5.8
New Pays	1	2	15	21	— 28.6
Total Discoveries	135	118	1,114	1,048	+ 6.3
Extensions to Fields	32	29	279	230	+ 21.3
Oil Fields	28	25	246	204	+ 20.6
Distillate Fields	1	1	9	14	— 35.7
Gas Fields	3	3	24	12	+100.0
Total Prod. Tests	167	147	1,393	1,278	+ 9.0
Dry Holes	682	636	5,767	4,889	+ 18.0
Wildcats	642	608	5,543	4,806	+ 15.3
New Pays	1	1	8	10	— 20.0
Outposts	39	27	216	73	+195.9
Total Explitory Tests	849	783	7,160	6,167	+ 16.1
Percent Productive	19.7	18.8	19.5	20.7	
Percent Dry	80.3	81.2	80.5	79.3	

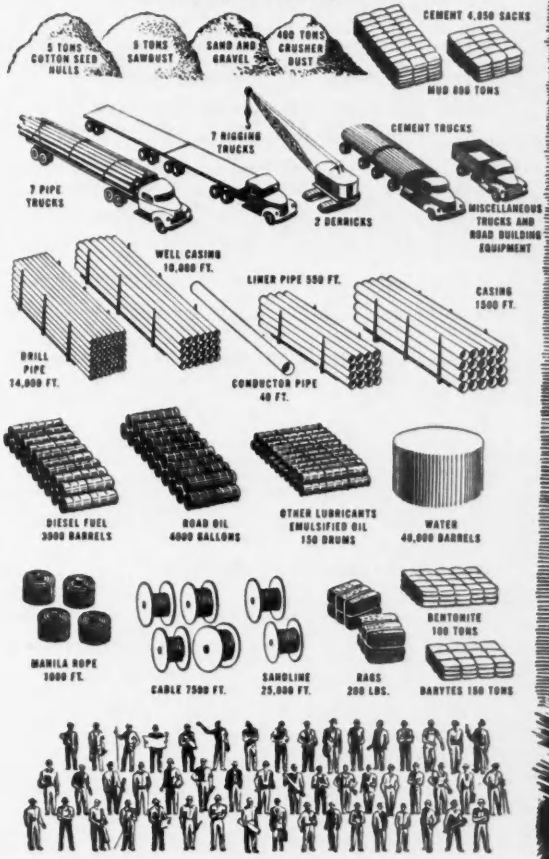
(See tables on 94-96.)

Results of Exploratory Drilling in October and First Ten Months, 1950-1949, by Districts

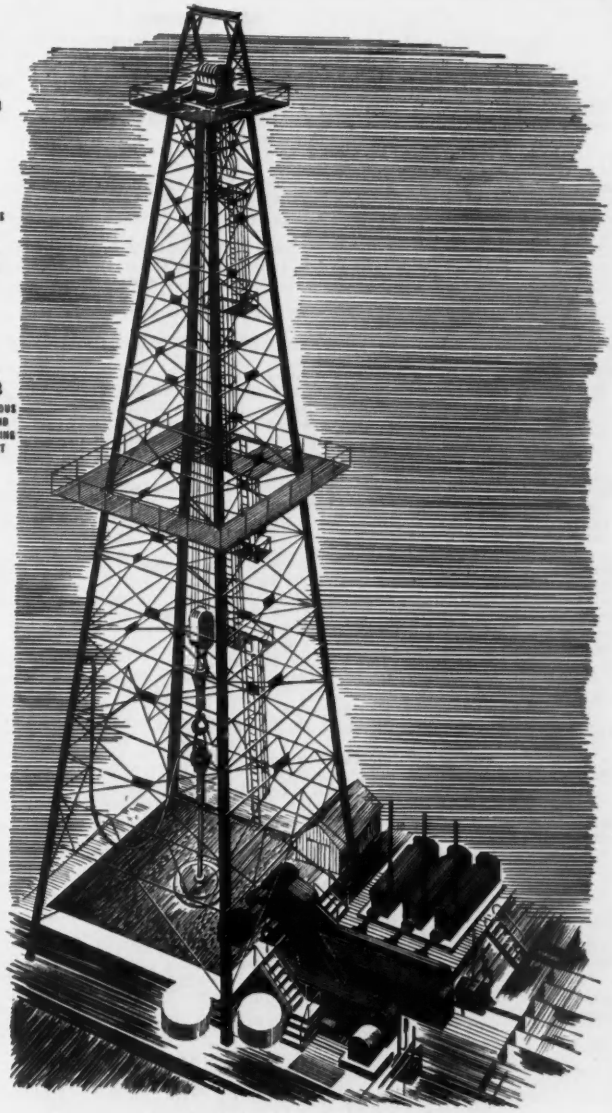
State or District	MONTH OF OCTOBER, 1950													FIRST TEN MONTHS, 1950																	
	Productive Tests									Total Productive	Unproductive Tests			Total Exploratory Tests	Productive Tests								Total Productive		Unproductive Tests			Total Dry		Total Exploratory Tests	
	New Fields			New Pays			Extensions								New Fields			New Pays			Extensions										
	Oil	Dis.	Gas	Oil	Dis.	Gas	Oil	Dis.	Gas		Wildcats	New Pays	Outposts		Oil	Dis.	Gas	Oil	Dis.	Gas	Oil	Dis.	Gas	10 Mo. 1950	10 Mo. 1949	Wildcats	New Pays	Outposts	10 Mo. 1950	10 Mo. 1949	10 Mo. 1950	10 Mo. 1949
Alabama											2			2	1		1							2		16			16	11	18	11
Arizona											1			1												5			5	5	5	5
Arkansas											4			4	6	1		1			1			9	14	70		2	72	65	81	79
California											23		8	31	15		1	5		1	18		3	43	37	287	3	26	316	310	359	347
Colorado									1	1	6		1	8	5		1			1			1	8	1	41		3	44	38	52	39
Florida																										8			8	13	8	13
Georgia																										4			4	4	4	4
Idaho											1			1												4			4		4	
Illinois	2						6			8	52			60	20			19			56		2	97	96	588			588	505	685	601
Indiana	6			1			1			8	32			40	35			7			5			47	45	391		13	404	317	451	362
Kansas	9						1			10	73			83	85		5	1			2			93	82	513			513	318	606	400
Kentucky											12			12	12			1	2		2			17	14	83			83	43	100	57
Louisiana	7	1		3	1		1			13	28			41	27	9	2	17	9	3	9	2	2	80	99	196	1	2	199	186	279	285
North Louisiana	6									6	18			24	11	1		2	4	3	5		1	27	28	97	1	2	100	104	127	132
South Louisiana	1	1		3	1		1			7	10			17	16	8	2	15	5		4	2	1	53	71	99			99	82	152	153
Maryland											2			2				1						1	1	3			3		4	1
Michigan	5			2		1				8	34			42	26		4	3		1	2			36	24	246			246	256	282	280
Mississippi	1									1	12			13	9	2		1				2		14	8	116	1	3	120	100	134	108
Missouri											3			3												6			6	13	6	13
Montana											6		1	7							2		1	3	7	46		1	47	33	50	40
Nebraska			2							2	6			8	3		4				3		1	11	1	48			48	5	59	6
New Mexico	2		1	1						4	7			11	11		2	5			8			26	21	58		6	64	50	90	71
North Dakota																														3		3
Ohio											4			4							2		2	4	3	13			13	29	17	32
Oklahoma	6			2			6			14	57			71	63	2	6	26	1		37	1	2	138	113	435			435	362	573	475
Pennsylvania																	1							1	2					1	1	3
South Dakota																										6			6	6	6	6
Tennessee																									1	4			4	20	4	21
Texas	44	5	7	16	2		13	1	2	90	267	1	27	385	347	44	77	140	7	9	93	4	10	731	665	2262	2	148	2412	2062	3143	2727
Dist. 1 S. Central	4			1			1			5	18		1	24	14	2	1		1	1	1			20	20	163		3	166	197	186	217
Dist. 2 Middle Gulf	3	2	2	1				1	1	10	20		5	35	13	9	16	11	2	4		2	4	61	61	127		16	143	139	204	200
Dist. 3 Upper Gulf	3		1	4			6			14	21		1	36	17	13	5	35	2	2	13	2	4	93	101	188		14	202	201	295	302
Dist. 4 L. Gulf-SW	4	2		3	2					11	16		3	30	21	8	19	36	2	2				88	97	231		8	239	283	327	380
Dist. 5 E. Central	1									1	6			7	5	1	1	1			1			9	4	59			59	62	68	66
Dist. 6 Northeast				2			1		1	4	12			16	7	4		4			4		2	21	19	66	1	5	72	61	93	80
Dist. 7-B N. Cent.	18		3	1			3			25	57		1	83	127	3	17	10			10			167	132	569		19	528	470	695	602
Dist. 7-C W. Cent.	2	1		1			1			5	31	1	5	42	22	3	4	8			7			44	35	169	1	19	189	83	233	118
Dist. 8 West	5		1	4			1			11	35		3	49	49		1	27			34			111	80	241		19	260	156	371	236
Dist. 9 North	4									4	49		8	61	71	1	13	8			23			116	115	500		45	545	404	661	519
Dist. 10 Panhandle											2			2	1									1	1	9			9	6	10	7
Utah																		2						2	3	13			13	20	15	23
Washington															1									1		1			1		2	
West Virginia																									10				4		14
Wyoming	2		3	3						8	10		2	20	11		3	9			6			29	31	80	1	12	93	110	122	141
Total U.S.	84	6	13	28	3	1	28	1	3	167	642	1	39	849	677	58	109	238	17	15	246	9	24	1393	1278	5543	8	216	5767	4889	7160	6167



Seismographic crew equipment . . . location crew equipment . . . welding equipment . . . directional survey tools.



One hundred and thirty two men who are experts in many fields—law, geology, engineering, drilling, trucking, carpentry, derrick building, chemistry, mechanics and so forth.



One completed oil derrick with all its diesel engines, bits, fishing tools, reamers and other equipment.

Want to drill an oil well? Here's all you need

There *may* be oil under your backyard . . . but you might as well face the fact that it will take a bit of doing to find out.

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Also Important Extensions to Established Fields

COUNTY	FIELD	COMPANY, WELL AND LOCATION	Date Completed	Total Depth (Feet)	Completion Horizon (Feet)	[1]Name, Character and Age of Producing Formation	[2]Initial Production Method and Choke	Gravity of Oil
		COLORADO—Gas Field Extension						
Morgan	Lee	J. M. Huber's Gov't. Smith 1, SE SW NW 1-2n-57w. ½ mi ne ext.	10-23-50	5530	5442- 5455	Muddy & Dakota sd; Cre.	No gge.	
		ILLINOIS—New Oil Fields						
Fayette	Patoka, W.	C. J. Simpson's F. Bonnell 1, NW NW NE 15-4n-1w	10-24-50	1425	1415- 1423	Bethel sd; Miss.	P 12; 80 wtr.	
Richland	Calhoun, Cent.	Sanders & Fye's C. Wells 1, NW SW SE 3-2n-10e	10-17-50	3284	3278- 3281	McClosky li; Miss.	P 8	
		ILLINOIS—Oil Field Extensions						
Clay	Iola, S.	Shulman Bros' V. Gibson 1, NW SE NW 14-4n-5e. 1 mi s ext.	10-31-50	2475	2463- 2474	Bethel sd; Miss.	P 75; 5 wtr.	
Hamilton	Rural Hill	D. Hopkins' Burnett-Johnson Comm. 1, NW NE SE 26-6s-5e. ½ mi ext.	10-17-50	3362	3166- 3176	Aux Vases sd; Miss.	P 45; 50 wtr.	
Madison	Livingston	S. Lalor's Quade 1, SW NE SE 21-6n-6w. 1 mi n ext.	10-10-50	493	480- 493	Pennsylvanian sd; Penn.	P 35	
Wayne	Clay City-Noble	A. Sturm & Sons' Gaston Hrs. 1, SE NW NW 25-1s-6e. ½ mi ext.	10-10-50	3121	3095- 3109	Aux Vases sd; Miss.	P 119	
Wayne	Ellery, W.	Aurora & N. V. Duncan's Scott 1, NE NE NE 27-2s-9e. ½ mi s ext.	10-17-50	3337	3290- 3304 3316- 3318	L. O'Hara li; Miss. Rosiclare li; Miss.	P 350	
White	Goldengate	E. A. Obering's Stephens-Pollard 1, SW SW NW 35-3s-9e. ½ mi w ext.	10-10-50	3460	3386- 3398	Rosiclare li; Miss.	P 20	
		INDIANA—New Oil Fields						
Dubois		Gale & Walters' W. E. Struckman 1, NE NE NW 17-3s-5w	10-13-50	925	922- 925	Rosiclare li; Miss.	P 12; 25 wtr.	
Gibson		L. Galambos Tr. et al's Anna B. Phillips 1, SW SW SE 9-3w-13w	10-14-50	1186	1178- 1186	Mansfield sd; Penn.	P 95	
Gibson		Joe Resnik & R. Halbert's Dan Weis 1, SW NW SW 14-4s-10w	10-25-50	1828	1808- 1828	Jackson sd; U. Miss.	P 50	
Knox		Graham Dev. Co's Anna E. Myers 2, NE NW NW 13-2n-9w	10- 5-50	1505	1502- 1505	Aux Vases li; Miss.	P 300	
Posey		Garfield & Atha's Bolger-Benson 1, NW SW NW 31-6s-13w	10-22-50	1478	1463- 1478	Mansfield sd; Penn.	P 23	
Warrick		Nat'l. Assoc. Pet. Co's Chas. Yeck 1, SW NE NW 28-4s-9w	10-11-50	2082	1890- 1900	McClosky sd; L. Miss.	P 14; 6 wtr.	
		INDIANA—New Oil Pay						
Daviess	Cannelburg	Stoner & Baker's R. Neukom 1, SW SW SW 17-2n-5w	10-12-50	841		Aux Vases li; Miss	P 10	
		INDIANA—Oil Field Extension						
Gibson	Union-Bowman	Hayes & Kennedy's C. Graulich 1, SE NW SE 33-1s-9w. ½ mi s ext.	10- 6-50	1691	1603- 1608	Aux Vases li; Miss.	P 82	
		KANSAS—New Oil Fields						
Barton	Redwing	E. H. Adair et al's Eveleigh 1, SE SE SE 31-17s-12w	10-29-50	3343	3335- 3343	Arbuckle li; Ord.	P 108	
Barton	Zink	Holl & Branine's Zink 1, SE SE NE 13-18s-11w	10- 5-50	3286	3284- 3286	Arbuckle li; Ord.	P 35	
Barton	Leoville	Lindas Oil Co's Schmid 1, NW NW NW 7-17s-14w	10- 3-50	3469	3464- 3469	Arbuckle li; Ord.	P 91	38
Cowley	Bruce	E. B. Shawyer et al's Davis 1, NE NE NW 9-30s-4e	10- 6-50	3313	3305- 3313	Arbuckle li; Ord.	P 40	25
Graham	Houston	Musgrove Pet Co's Rush 1, NW NE NE 9-6s-22w	10- 7-50	3663	3578- 3582	Lansing- K.C. li; Penn.	P 413	
Kingman	Broadway	Earl Wakefield's Broadway 1, SE SE NW 21-28s-5w	10- 3-50	4361	3832- 3836	Mississippi dolo; Miss.	F 25	32.5
Stafford	Leo	Petroleum, Inc's Hall 1, SE SE SW 7-21s-13w	10- 4-50	3640	3635- 3640	Arbuckle li; Ord.	P 29	
Sumner	Portland	Herndon Drlg's Hunt 2, SW SE NW 16-34s-1e	10-15-50	4004	3999- 4004	Simpson sd; Ord.	P 160	44
Wabaunsee	Newbury	Skelly Oil Co's Fearon 1, NW SW NE 11-11s-11e	10- 5-50	2904	2901- 2904	Viola li; Ord.	P 254	
		KANSAS—Oil Field Extension						
Phillips	Huffstutter, W.	Honaker Drlg's Brockett 1, SW SW SW 30-1s-18w. ½ mi nw ext	10-12-50	3540	3518- 3523	Lansing- K.C. li; Penn.	P 317	
		NORTH LOUISIANA—New Oil Fields						
Catahoula	"Pool Lake"	Pan-Am Southern & Austin Stewart's Gillis 1, C SW SW 14-8n-7e	10-29-50	6512	4639- 4640	Wilcox sd; Eoc.	F 100; $\frac{3}{64}$"	38.5
De Soto		Lyons et al's Sue Chaffin et al 1, C SW SW SE 4-12n-14w	10- 3-50	3301	2945- 2950	Paluxy sd; Cre.	P 100	40
Grant		Justiss Mears et al's Erwin Hrs. 1, SE NE 27-6n-2e	10- 2-50	5205	2424- 2430	Sparta sd; Eoc.	P 30	
La Salle	"Saline Lake, N."	Hunt Oil et al's La. Delta Lbr. 25, Sect. 25-5n-4e	10-19-50	6005	5485- 5490	Wilcox sd; Eoc.	F 210; $\frac{3}{16}$"	42
Natchitoches		D. B. McConnell et al's T. J. Wilkerson 1, Sect. 30-11n-10w	10-17-50	2828	2810- 2828	Fredericksburg li; L. Cre.	F 30; $\frac{3}{32}$"	40.6
Richland		Don Montgomery et al's May-Dunlap 1, Sect. 35-17n-9e	10- 5-50	4010	3756- 3762	Tuscaloosa sd; Cre.	F 237; $\frac{3}{16}$"	41.6
		SOUTH LOUISIANA—New Oil Field						
Plaquemines	Cox Bay	Richardson & Bass' St. 1794-Orleans Lev. Dist. 2-H, Sect. 5-18s-16e	10-30-50	10954	9710- 9720		F 260; $\frac{3}{64}$"	36.4
		SOUTH LOUISIANA—New Oil Pays						
Acadia	Midland	Sun & Sohio's Le Blanc 1, Sect. 55-10s-2w. 1½ mi sw ext.	10-17-50	11725	11574-11582	Miocene sd; L. Mio.	F 110; $\frac{1}{8}$"	43.7
Plaquemines	Delta Duck Club	Texas Co's St. Lse 335-2, Sect. 36-20s-19e	10-23-50	11900	11766-11784	Miocene	F 237; $\frac{1}{8}$"	36
Plaquemines	Lk. Washington	Texas Co's St. Cockrell 1, C NE SE 8-20s-27e	10- 2-50	10992	10127-10138	Miocene	F 291; $\frac{1}{8}$"	35.8
		SOUTH LOUISIANA—Oil Field Extension						
Calcasieu	DeQuincy	Niloco's Daisy P. Kanouse 1, NE SE 3-8s-11w. 1 mi w ext	10-23-50	6670	6660- 6670	Moicene sd; L. Mio.	F 61; $\frac{1}{8}$"	28.4
		SOUTH LOUISIANA—New Distillate Field						
Terrebonne	"Kent Bayou"	Union Prod. Co's Cont. L&F Co. 1, Sect. 35-17s-13e	10- 7-50	11957	11085-11104		F no gge; 56 mln; open	53.2
		SOUTH LOUISIANA—New Distillate Pay						
Terrebonne	Turtle Bayou	Shell's Cont. L&F Co. 3, C NE SE 28-17s-14e. 1½ mi ne ext.	10- 1-50	14000	11233-11241	Miocene	F 26; 1.8 mln; $\frac{1}{8}$"	46
		MICHIGAN—New Oil Fields						
Allegan		James J. McGerry's Tr.'s Smith 1, NW NW NW 9-1n-12w	10-13-50	1457	1454- 1457	Traverse li; Devo.	P 20	
Allegan		Kisner & Laue's Worst Est. 1, NE NE NE 32-4n-13w	10-15-50	1659	1654- 1659	Traverse li; Devo.	P 60	
Bay		Hilliard's Bay Tr. Co. & Castle 1 (OWWO), NW NW NW 23-16n-3e	10-13-50	3354	3199- 3333	Dundee li; Devo.	P 44	
Ionia		Mercer Oil Co's Schafe 1, SE SE SW 18-8n-5w	10-16-50	2993	2970- 2991	Dundee li; Devo.	P 4	
Van Buren		Ford Henry's Cooley 1, NW NW NW 10-1s-13w	10- 2-50	1399	1398- 1399	Traverse li; Devo.	P 20; 50 wtr.	
		MICHIGAN—New Oil Pays						
Gladwin	Billings	Socony Vacuum's McGrandell B-3, SW NW SW 2-17n-1e	10-14-50	4995	4078- 4091	Detroit River sd; Devo.	P 35	
Gladwin	Butman	H. E. Bell's Serlin & Kaminsky 1, NE NE SW 12-20n-1w	10-23-50	2791	2780- 2791	Traverse li; Devo.	P 72; 240 wtr.	
		MICHIGAN—New Gas Pay						
Osceola	Rose Lake	Brazos O&G Co's Compton Comm 1, C W/L SW 31-19n-9w	10-25-50	1375	1347- 1351	Stray sd; Miss.	F 1.1 mln.	
		MISSISSIPPI—New Oil Field						
Jefferson	Church Hill	Robert Oil & Lyle Cashion's Davis Hrs. 1, Sect. 41-9n-2w	10-20-50	7091	5535- 5537	Artman sd; Eoc.	F 150; $\frac{3}{32}$"	44
		NEBRASKA—New Gas Fields						
Cheyenne		Macauley & Dorough's Anderson 1, SE SE SE 12-13n-51w	10-12-50	5300	4660- 4672	"D" sd; Cre.	F 4.5 mln; $\frac{21}{64}$"	
Cheyenne		Ohio Oil Co's Fender 1, NW NW SW 2-14n-58w	10- 9-50	6814	4350- 4360	1st Dakota sd; Cre.	F 4.7 mln; open	
		NEW MEXICO—New Oil Fields						
Lea		McAlester Fuel's Brownfield 1-A, C NW NE 24-12s-37e	10- 1-50	12035	11785-11840	Devonian li; Devo.	F 335; $\frac{1}{4}$"	46.8
San Juan		So. Union Prod. Co's Navajo 1, SW NE NE 1-21n-14w	10-27-50	3644	3545- 3550	Dakota sd; Cre.	P 35; 40 wtr.	
		NEW MEXICO—New Oil Pay						
Lea	Teague	Gulf's E. C. Hill 1, C NE SW 27-23s-37e	10-30-50	9785	9710- 9750	Ellenburger li; Ord	F 576; $\frac{3}{4}$"	45.3
		NEW MEXICO—New Gas Field						
San Juan		J. D. Hancock's Govt. Brit. Amer. 1, NE NW 26-27n-11w	10-16-50	6850	2042- 2110	Pict. Cliff. sd; U. Cre.	F 5 mln.	
		OKLAHOMA—New Oil Fields						
Cleveland	Roulette Cr.	V. A. Brill's Riordan 1, SE SE NE 16-8n-1e	10- 8-50	6427	6420- 6427	Wilcox sd; Ord.	F 321; $\frac{1}{4}$"	41.4
Lincoln	Belmont, W.	Anderson-Prichard's Bartodeji 1, NW SW SE 32-12n-5e	10-18-50	5053	5027- 5053	2nd Wilcox sd; Ord.	P 116	41.9
Lincoln		Delaney Drlg's Lytle 1, NE NE NE 17-13n-5e	10-12-50	3557	3535- 3557	Prue sd; Penn.	F 45; $\frac{3}{8}$"	
Love		Walter N. Gant's Reid 1, SW SW SW 2-7s-2e	10-19-50	6246	6030- 6060	Deese sd; Penn.	F 102; $\frac{11}{64}$"	42.9
Okfuskee		Kingery-Patterson's Seran 1, SE SW NW 12-12n-8e	10-29-50	4161	3965- 3980	Gilcrease sd; Penn.	P 70	22.8
Payne		W. H. Elson's Hesser 1, NE NE SW 4-19n-3e	10-23-50	4543	3508- 3522	Cleveland sd; Penn.	F 80; 10 wtr	
		OKLAHOMA—New Oil Pays						
Carter	Fox-Graham	Samedan Oil's Ferguson 6, SW SW NE 33-2s-3w	10-14-50	5895	5690- 5815	Pennsylvanian sd; Penn.	P 100	36
Major	Ringwood	Mazda Oil's Black 1 (OWDD) NE NW NW 12-21n-10w	10-23-50	7260	6360- 6455	Oswego li; Penn.	F 55; $\frac{1}{2}$"	
		OKLAHOMA—Oil Field Extensions						
Kay	Banner	Wood Oil's Buckles 1 (OWDD), SE SE SW 6-27n-2e, ¾ mi ext.	10- 2-50	4106	3542- 3590	Burbank sd; Penn.	F 28	40
McClain	Bradley, E.	Cities Service's Jones 1-C (OWWO) C NW NE 32-4n-4w. ¾ m se ext.	10-17-50	12510	10250-10268	Chimney Hill li; Devo.	F 218; $\frac{1}{2}$"	41
Payne	Un-named	Patton & Tully's Wilson 1, NW NW NW 1-18n-4e. ½ mi se ext.	10-25-50	3474	3452- 3473	Red Fork sd; Penn.	F 32	
Seminole	Hazel	W. A. Villines' Reed 1, SW SE NW 19-7n-6e. ⅝ mi ne ext.	10- 6-50	2525	2482- 2496	Calvin sd; Penn.	P 13; 38 wtr.	41.8
Seminole	Bethel, W.	Glober O&R Co's Haifen 1, SW SE SW 15-9n-7e, west ext.	10- 6-50	3505	3465- 3505	Cromwell sd; Penn.	F 35; 20 wtr; $\frac{A}{A}$"	
Stephens	Camp, NW	Stanolind's Chickasaw Inv. 1, SE SE SE 2-2s-4w. ¾ mi n ext.	10-11-50	6000	5660- 5684	Pennsylvanian sd; Penn.	F 500; $\frac{1}{2}$"	35
		TEXAS—District 1 (SOUTH CENTRAL)—New Oil Fields						
Bastrop		Adams & Jackson's Duran 1, A. Flint Sur.	10-12-50	2237	2164- 2182		P 12	42
McMullen	Dilworth	H. R. Smith & Am. Republic's Dilworth Jr. 1, R. Vasquez Sur. 42	9-21-50	8074	4929- 4934		F 130; $\frac{1}{32}$"	36
Milam		G. A. Wilson's H. P. Culpepper 1, B. W. Holtzclaw Sur.	8-26-50	496	341- 361		P 6	42
Travis	"Elroy"	Anderson Prichard's A. C. Jacobson 1, M. Green Sur. 314	10-20-50	836	815- 836	Serpentine sd; U. Cre.	P 10; 68 wtr.	34

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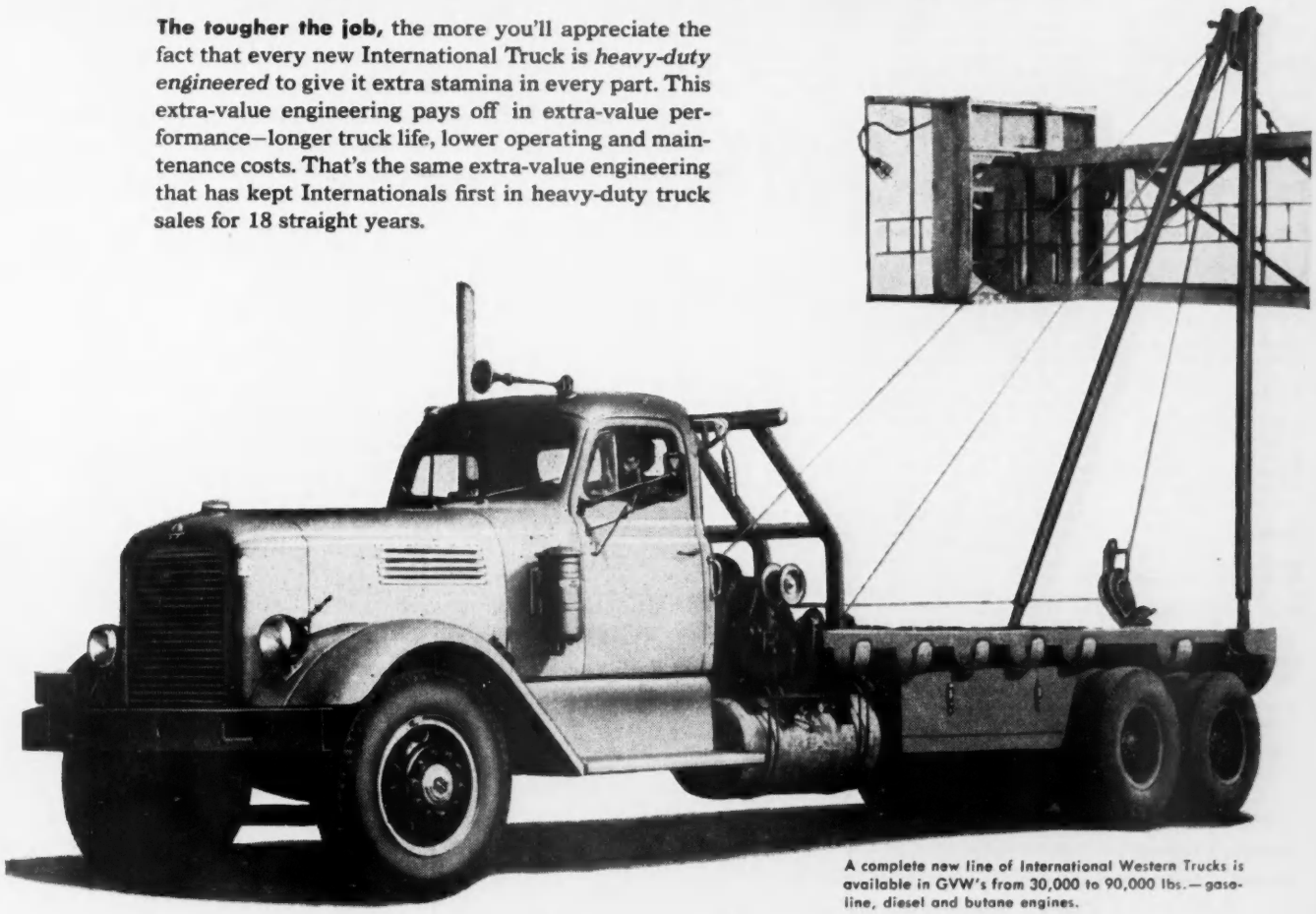

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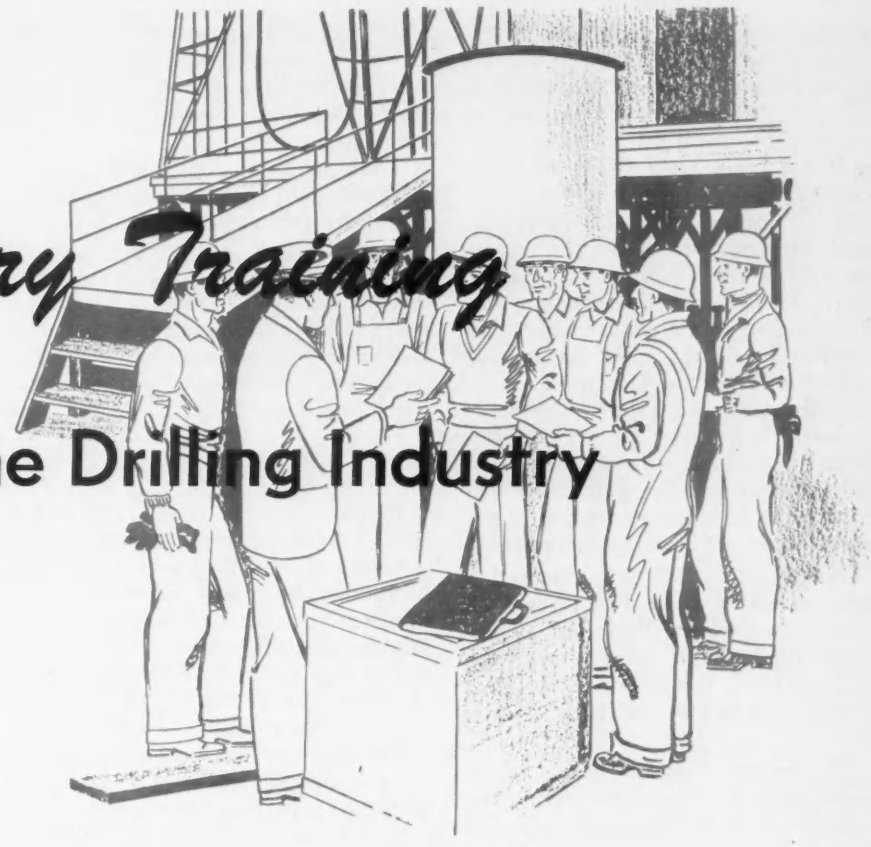
COUNTY	FIELD	COMPANY, WELL AND LOCATION	Date Completed	Total Depth (Feet)	Completion Horizon (Feet)	[1]Name, Character and Age of Producing Formation	[2]Initial Production Method and Choke	Gravity of Oil
		TEXAS—District 1 (SOUTH CENTRAL)—Oil Field Extension						
Travis	"Elroy"	Anderson Prichard's J. A. Martin Est. 2, M. Green Sur, 1 mi sw ext.	10-28-50	662	650- 662	Serpentine sd; U. Cre.	P 81	35
		TEXAS—District 2 (MIDDLE GULF)—New Oil Fields						
Bee		Morris Cannan & Texita's Tom 1, H. H. Williams Sur.	10- 9-50	4197	4188- 4197		F 35; 140 wtr; 1/4"	23
De Witt	"Helen Gohlke"	Shell's Gohlke Hrs. 1, T. J. Thigpen Sur.	10-12-50	8514	8142- 8147	Wilcox sd; Eoc.	F 320; 1/4"	32
Refugio		Arnold Morgan's F. J. Boehm 1, Esteban Lopez Sur.	10-18-50	7856	6302- 6306		F 113; 1/64"	43
		TEXAS—District 2 (MIDDLE GULF)—New Oil Pay						
Refugio	Mission River	Kirkwood & Taggart's St Jno. Hrs. 1-A, Refugio Twn. Gr.	10-21-50	7519	5558- 5566	Frio sd; Olig.	F 88; 1/8"	36
		TEXAS—District 2 (MIDDLE GULF)—New Distillate Fields						
Bee	"Papalote"	W. R. Quin et al's J. A. Hynes 1, T. Hart Sur. A-28.	9- 5-50	5596	5530- 5531		F no gge; 3.7 mln.	
De Witt	Barry	United Prod. Co's A. J. House 1, Thos. Barry Sur.	10- 7-50	7806	5336- 5346	Yegua sd: Eoc.	F 175; 31 mln.	
		TEXAS—District 2 (MIDDLE GULF)—Distillate Field Extension						
Lavaca	Provident City	Salt Dome & Skelly's Merecka et al 1, J. Merecka Sur. 1 mi se ext.	10-12-50	9119	8932- 8996	Wilcox sd; Eoc.	F 22; 21 mln.	49.3
		TEXAS—District 2 (MIDDLE GULF)—New Gas Fields						
Bee		C. G. Glasscock's Mrs. Sudie Scott 1, Jose Maria Uranga Gr.	10-30-50	4600	3272- 3278		F 2.8 mln; open	
Victoria		Robt. Reisenberg, Trs' W. L. Lipscomb 1, R. Rios Sur. 283.	10-23-50	3856	3846- 4852		F 17 mln; open	
		TEXAS—District 2 (MIDDLE GULF)—Gas Field Extension						
Goliad	Sarco Crk.	Ginther, Warren & Ginther et al's C. G. Wood 9, Pedro Villa Sur. 3/4 mi n ext.	10-12-50	8372	2897- 2904 4348- 4352	Frio sd; Olig. Frio sd; Olig.	F 20 mln; open F 10 mln; open	
		TEXAS—District 3 (UPPER GULF)—New Oil Fields						
Fayette		Armstrong & Sutton's F. A. Kemel 1, Sam Millet Sur.	8-30-50	1159	1129- 1159		P 20	24.6
Hardin		J. K. Hughes Oil Co's A. N. Blackwell 1, S. R. Brown Sur.	10-30-50	8320	7173- 7175		F 53; 3/32"	36.4
Liberty		J. W. Mecom's E. F. Failor 1, W. S. Swilley Sur. 188.	10-29-50	8300	7678- 7690	Yegua sd: Eoc.	F 329; 1/16"	39.8
		TEXAS—District 3 (UPPER GULF)—New Oil Pays						
Austin	New Ulm	New Ulm Corp's Adolph Weige 1 (OWWO), Jas. Tylee Sur.	10-12-50	11071	9356- 9374		F 228; 7/32"	43
Brazoria	Nash	Dan J. Harrison, Jr's Belle Wisdom Est. 5, H. N. Cleveland Sur.	10-20-50	4744	4418- 4439	Anahuac li; Olig.	F 86; 18/64"	20.7
Wharton	Gobbler Cr.	Grubb & Hawkins' G. H. Harfst 1, Lyman Conkrite Sur. 16.	10-28-50	5325	4717- 4720		F 125; 1/8"	25.5
Wharton	Hilje, S.	Sam G. Harrison's Niels Carlsen 1, Morris & Cummings Sur.	10- 2-50	6015	5236- 5241		F 121; 9/64"	36.5
		TEXAS—District 3 (UPPER GULF)—Oil Field Extensions						
Austin	New Ulm	New Ulm Corp's A. H. Peschel 1-A, Felix Wright Hrs. Sur. 314 3/4 mi e ext.	10-28-50	10173	9039- 9075	Wilcox sd; Eoc.	F 227; 13/64"	36.7
Galveston	Gillock	J. W. Mecom's Maco Stewart 18-A, W. K. Wilson Lge. 1/2 mi w ext.	10- 1-50	9000	8904- 8916	Frio sd; Olig.	F 113; 1/4"	38.2
Galveston	Gillock, S.	Pan Am Prod's S. Gillock Comm. 1-J, J. D. Moore Sur. 1/2 mi se ext.	10-16-50	9503	9400- 9408	Frio sd; Olig.	F 198; 5/16"	37.2
Jefferson	W. Beaumont	Sam Maceo's L. G. Black Tr. 1, H. Williams Lge. 3/4 mi s ext.	10- 2-50	7700	5857- 5867		F 66; 1/8"	29
Jefferson	Rose City	H. L. Hawkins' L. Cartwright 1, David Brown Lge. 1/2 mi sw ext.	10-31-50	8181	8138- 8142	Hackberry sd; Olig.	F 233; 3/8"	38.9
Newton	Gist	Standard & Tex's Mrs. Jennie W. Watson 1, M. A. Watson Sur. 1/2 mi e ext.	10-13-50	7292	7193- 7194	Frio sd; Olig.	F 155; 1/8"	40
		TEXAS—District 3 (UPPER GULF)—New Gas Field						
Harris		Texas Co's Mrs. E. Hope Norris 1, I&GN RR Sur.	10-18-50	8009	7576- 7586		F 7 mln; open	
		TEXAS—District 4 (LOWER GULF-SW)—New Oil Fields						
San Patricio	"Harvey"	La Gloria's J. H. Harvey 1, Blk 9, Rincon Road Subd.	10-26-50	9976	8208- 8210		F 184; 11/64"	43.6
San Patricio	"Durham"	Seaboard's R. H. Welder 1, Sect. 38, Welder Reh. Subd.	10-15-50	8273	7136- 7140		F 93; 1/8"	40.9
San Patricio		Union Oil's R. H. Welder 2, H. O'Neill Sur.	10-27-50	7995	4124- 4126		F 40; 3/32"	21.7
Starr	"Marks"	Ben D. Marks' Tr's Down Roy. Corp. 1, Beer & Coffey Subd. El Javali Gr.	10-14-50	2130	2125- 2130	Colorado sd; Eoc.	P 111	33.8
		TEXAS—District 4 (LOWER GULF-SW)—New Oil Pays						
Duval	Rowden, N.	Rowden & Moulder's Weil-Colvin 1, BS&F Sur. 567.	10-21-50	2715	1730- 1741	Frio sd; Olig.	P 43	22
Jim Wells	Seeligson	Magnolia's A. A. Seeligson 168, Los Jaboncillos-A. Ramirez Sur.	10-12-50	7002	6809- 6813	22 "E" sd; Olig.	F 144; 9/64"	37.9
San Patricio	Sinton, W.	Plymouth's Welder 9-A, E. H. Welder Reh. Subd, de la Garza Sur.	10-21-50	7202	6696- 6698		F 66; 3/32"	40.2
		TEXAS—District 4 (LOWER GULF-SW)—New Distillate Fields						
Hidalgo		Taylor Refg. et al's Pearl Keirn Unit 1, Blk 7, Hidalgo Canal Co. Subd.	10-13-50	10270	9010- 9375		F 10; 15 mln.	51.8
Webb	"Withers"	Seaboard's Mary K. Withers 1, BS&F Sur. 40.	10-10-50	6725	6500- 6510	Wilcox sd; Eoc.	F 20; 22 mln.	61.5
		TEXAS—District 4 (LOWER GULF-SW)—New Distillate Pays						
Hidalgo	La Reforma	Chicago Corp's Theresa Barrera 2, San Jose Gr.	10- 3-50	6737	6231- 6239	"F" sd; Olig.	F 75; 2.5 mln.	64.7
Nueces	Mustang Island	Atlantic & Tide Water's State 436-1 (OWWO) State Tr. 436.	10- 6-50	9525	7506- 7618	5th zone; Olig.	F 813; 48 mln.	56.9
		TEXAS—District 5 (EAST CENTRAL)—New Oil Field						
Falls		Hill & Brian's Charley Becker 1, (OWWO), A. Montgomery Sur.	9-11-50	1350	1085- 1095	Eagleford li; U. Cre.	P 128	36.2
		TEXAS—District 6 (NORTHEAST)—New Oil Pays						
Anderson	Tennessee Colony	Continental's Royall Nat'l Bk 2, A. G. Monroe Sur.	10- 9-50	9820	9626- 9646	Pettit li; L. Cre.	F 492; 1/4"	53.4
Cherokee	Jacksonville, N.	Union's W. O. Prestidge 1, John Blanton Sur.	10-12-50	4529	4450- 4455	Woodbine sd; U. Cre.	F 56; 3/16"	40.4
		TEXAS—District 6 (NORTHEAST)—Oil Field Extension						
Smith	Red Springs	Sells Pet's Oliver Hackett 1 (OWDD), Sam. Leeper Sur. 1 mi sw ext.	10-24-50	9401	9174- 9184	Rodessa li; L. Cre.	F 91; 1/8"	48.3
		TEXAS—District 6 (NORTHEAST)—Gas Field Extension						
Harrison	Woodlawn	Stanolind's Griffis Gas Unit 1, G. W. Reynolds Sur. 1 mi sw ext.	10-16-50	6648	6479- 6590	Pettit li; L. Cre.	F 14 mln; open	
		TEXAS—District 7-B (WEST CENTRAL)—New Oil Fields						
Runnels		J. A. Messinger's Nora M. Jones 1, Blk 535, E. Mathers Sur.	10- 5-50	4108	4075- 4081	Gardner sd; Penn.	F 135; 3/16"	46.8
Schleicher		Delta Gulf Drlg. et al's H. F. Thomson 1, Sect. 71, Blk TT, TCRR Sur.	10-25-50	5803	5772- 5775	Strawn Reef li; Penn.	F 1456; 3/4"	42
		TEXAS—District 7-C (WEST CENTRAL)—New Oil Pay						
Coke	Ft. Chadbourne	Humble's Odom-State 1, J. Hendry Sur.	10- 1-50	5798	5700- 5706	Ellenburger dolo; Ord.	P 22; 56 wtr.	41
		TEXAS—District 7-C (WEST CENTRAL)—Oil Field Extension						
Crockett	Pikes Peak	Oliver & Kityza & C. A. M.'s Geo. Bean 1, GC&SF Sur. 11 mi nw ext.	10- 2-50	1652	1232- 1269	Grayburg li; Perm.	P 47	36.4
		TEXAS—District 7-C (WEST CENTRAL)—New Distillate Field						
Irion		Wilshire Oil's Brooks 1-A, Sect. 21, Blk 3, H&TC Sur.	10-18-50	7657	5865- 5985	Wolfcamp sd; Perm.	F 24; 1-2 mln.	63.7
		TEXAS—District 8 (WEST)—New Oil Fields						
Andrews		Garrett M. Smith's McWhorter-Hall 1, Sect. 8, Blk A-29, PSL Sur.	10- 4-50	7508	7349- 7508	Wichita Albany li; Perm.	F 198; 7/64"	37.6
Dawson		Fred M. Manning's D. Huddle 1, Sect. 11, Blk 36, T&P Sur.	10-17-50	9914	7856- 7985	Sprayberry sd; Penn.	F 186; 32/64"	37.9
Kent		Star Oil's Blanch Young 1, Sect. 54, Blk 5, H&GN Sur.	10-15-50	7822	7786- 7822	Ellenburger dolo; Ord.	F 1477; 3/4"	41.2
Winkler		Cities Service's R. F. Waddell 1, Sect. 5, Blk B-7, PSL Sur.	10-11-50	10860	9380- 9400	Fusselman li; Ord.	F 1738; 3/4"	32
Yoakum		Dunigan & Brahaney's Henard 1, Sect. 367, Blk D, J. H. Gibson Sur.	10-28-50	5285	5205- 5285	San Andres li; Perm.	P 58	32
		TEXAS—District 8 (WEST)—New Oil Pays						
Andrews	Emma	Forchall Oil's Emma Cowden 3 (OWDD), Sect. 1, Blk 44, T&P Sur.	10-27-50	5146	5122- 5146	Holt li; Perm.	P 50	33
Ector	Yarbrough & Allen	Amerada's Carlinville Nat'l Bk 1, Sect. 18, Blk 46, Gunter & Munson Sur.	10- 6-50	10710	10110-10130	Waddell sd; Ord.	F 227; 1/4"	39.1
Gaines	Robertson	Shell's T. O. Stark 1, Sect. 12, Blk A-24, PSL Sur.	10- 4-50	12120	8980- 9050	Canyon Reef li; Penn.	F 143; 1/2"	46.2
Kent	Polar E.-Penn	Kewanee Oil's Wil D-2, H&GN Sur. 1/2 mi nw ext.	9-28-50	7443	7191- 7211	L. Strawn sd; Penn.	F 950; 2"	41.3
		TEXAS—District 8 (WEST)—Oil Field Extension						
Kent	Salt Creek	General Crude & Percy Jones' Coleman 1, W&NW Sur. 1 mi w ext.	10- 4-50	6560	6416- 6460	Canyon Reef li; Penn.	F 586; 5/8"	40
		TEXAS—District 8 (WEST)—New Gas Field						
Pecos		J. S. Merriwether, Jr's Leon Fms Corp A-1, Sect. 311, C. McKeley Sur.	10-10-50	2868	2718- 2868	Yates sd; Perm.	F 9 mln; 2"	
		WYOMING—New Oil Fields						
Johnson		American Liberty Oil's Irvine 1, NW NW NE 7-41n-77w.	10-22-50	7492	7472- 7492	Lakota sd; L. Cre.	F 265; 13/64"	
Washakie		General Pet's Gov't 84-32, SE SE SE 32-47n-92w.	10-13-50	10554	10460-10554	Embar li; Perm.	F 684; 3/8"	32.4
		WYOMING—New Oil Pays						
Hot Springs	Golden Eagle	Phillips Pet. Co's Golden Eagle 2, NW NW SW 12-45n-97w.	10-17-50	9339	8890- 8930	Phosphoria li; Penn.	F 1115; 13/64"	48.4
Hot Springs	Lake Creek	Pacific Western Oil's Unit 5, 14-43n-92w.	10-11-50	3367	3253- 3367	Embar li; Perm.	P 365	
Johnson	Meadow Crk.	Continental's Unit 15, SW NW NE 11-41n-78w.	10-30-50	6574	6489- 6554	Wall Creek sd; U. Cre.	F 12; 1/8"	
		WYOMING—New Gas Fields						
Carbon		Amerada Pet.'s Unit 1, C SW SE 30-16n-90w#	10- 5-50	8275	2436- 2494	Mesaverde sd; U. Cre.	F 3.7 mln.	
Converse		El Capitan Drlg. Co's Silvers 1, NW NW NW 21-32n-71w.	10-28-50	3200	740- 750		F 2 mln.	
Fremont		British American's Gov't-Heaney 1, (OWWO) C NW NE 5-31n-94w.	10-15-50	6306	5191- 5226	Phosphoria li; Penn.	F 6.5 mln.	

[1] Character of producing formations abbreviated thus: ch, chalk; Dolo, Dolomite; li, limestone; sd, sandstone; sh, shale; ser, serpentine; cgl, conglomerate. Ages of formation abbreviated thus: Plio, Pliocene; Mio, Miocene; Olig, Oligocene; Eoc, Eocene; U. Cre, Upper Cretaceous; L. Cre, Lower Cretaceous; Jur, Jurassic; Tri, Triassic; Perm, Permian; Penn, Pennsylvanian; U. Miss, Upper Mississippian; L. Miss, Lower Mississippian; Devo, Devonian; Sil, Silurian; Ord, Ordovician; Cam, Cambrian.

[2] Barrels of oil per day (24 hour rate), flowing (F), pumping (P), swabbing (Sw), or bailing (B); or million cubic feet of gas daily open flow capacity; size of choke in inches.

Supervisory Training In the Drilling Industry



By A. L. FRANZOLINO
Assistant Professor, Department of Personnel Administration, Southern Methodist University, Dallas

THE AUTHOR recently surveyed the drilling industry with reference to progress under the plan of supervisory training. He presents his findings in this paper, originally read before the annual meeting of the American Association of Oil Well Drilling Contractors at Tulsa in October. His conclusions indicate the success of the plan, and outline the many tangible results accruing.

AT LEAST two points should be clarified on the general subject of training.

The first point, which seems to be apparent, yet at the same time not too easily recognized by many employers, is that no organization in any industry is ever faced with the choice as to whether or not the employes of that organization should receive training. In this there is no choice. Whether or not the organization has a formal training program, somebody is going to give those employes training. Therefore, the directors of the organization have only the choice of deciding whether or not they wish to have a hand in controlling the accuracy of the information that is given and in selecting the men who are to explain the organization to the employes.

To initiate a formal training program is not to adopt something new, but merely to apply intelligent planning to something that has always existed. Planned training is designed, among other things, to eliminate the false impression, the inaccurate information, the misinterpretation of policies, workers' disinterest, and unjustified dissatisfaction that result from a too casual introduction of the employes to an organization.

Company experiences have taught that such planning pays dividends in many ways.

Point two is the question, "What is training?" The answer again appears to be so obvious that in many organizations very little consideration has been given to a thorough study of this question; yet if training is to be used effectively as a production tool of industry, the time has come when a more searching analysis is necessary.

Training has been defined as that tool of management which through the application of sound principles of teaching and learning is utilized to raise the production ability and to maintain and improve the performance of *all* employes, including management itself. Training should be recognized as the planned action that each member of management should take continuously in developing the abilities and performance of those working under him.

Training therefore becomes the direct concern of each member of management from the president to the foreman, the higher the position, the greater the responsibility.

No industry or business can function successfully in building sound relations between employer and employes until each member of management becomes fully conscious of the importance of his strategic position, and until he becomes human-relations-and-organization-conscious. Executives, managers, supervisors, any member of management—these are the key men in business and industry because they are the source of contact between capital and labor. It is their chief responsibility to bridge the gap between those who own or control the organization and those who are producing the goods or services.

Therefore this executive, this manager, this supervisor, must have a background with experiences and an insight sufficient to enable him to make a fair and consistent interpretation of the company to the workers, of the workers to the company, and of both to the public. This is the chief aim of any executive, managerial, or supervisory training program.

Learning is a continuous process; as we learn we develop habits of performances which may be either good or bad.

The purpose of Supervisory Training is to develop within supervisory personnel an understanding of sound

principles of management and supervision, to keep them informed regarding new techniques of supervision, and through repeated and various approaches to instill in them through habit the desire and ability to apply these principles.

It is accepted that the supervisor occupies a position of unique importance in our modern industrial system. To the employe his voice is the voice of management, while to higher executives, he is the chief avenue of contact with the working force. Wise, carefully planned industrial policies are ineffective unless applied with understanding by all supervisors. Supervisors are not merely agents and representatives of management, they are an essential part of management itself.

During June, 1950, I observed a program called "The Employer Unit Plan of Supervisory Training" as presented by training specialists of the University of Texas to the different drilling contractors and their personnel.

The express purpose of this observation was to determine what aid could be given to the training specialist in order to help him to do a better job and at the same time, to determine what tangible results the different drilling contractors were receiving from this program.

It seems that a little better than a year ago this program "The Employer Unit Plan of Supervisory Training" in the drilling industry was conceived and put into effect through the joint efforts of the University of Texas and the American Association of Oilwell Drilling Contractors.

Briefly, this program was designed for the different contractors and their personnel with the intent to develop leadership through group or collective thinking. In the main, it consisted of a series of conferences, each carefully planned in advance and presented to the drilling contractor and his personnel in order to demonstrate to him how to get results through his leadership of his staff. And in turn, how each of his superintendents, tool pushers, and drillers would achieve results through leadership of their men. The principal tool or method used in the program was the planned conference method.

The purpose of this program was derived from an analysis of the following points:

That accident-free operation result when management and men cooperate wholeheartedly to achieve the maximum efficiency. The right way to do a job will always be a safe way.

That achievement of the degree of cooperation required is the responsibility first of management; secondly, of line supervision; and finally of operating men. The job has to be done within the organization with management taking the lead.

That drilling contractors cannot solve the problem working separately and individually, since there is a constant shifting of operating personnel from one employer to another.

That education is the one effective tool available to management when it tackles the problem of procuring the maximum of efficiency and accident-free operations.

All-Embracing Program

It follows from these facts, then, that it is necessary to enter into a program of education which will take in management, supervisors and operating men. This program must also take in all drilling companies and all major drilling areas. In short, what is needed is an industry-wide and nation-wide program of education.

In observing this program I looked for many things but in the main there were two important ones which were:

1. The general attitude of the training specialist toward his work situation.

2. The general attitude of the drilling contractors, toolpushers, drillers and roughnecks toward the program.

In regard to the training specialist, it took these men on the average of 14 hours to prepare, present and report a single, one-hour rig meeting. (This 14 hours includes such factors as travel time, warmup time, etc.) Yet regardless of this, these men enjoyed doing their work because the men receiving the training wanted that training.

The general attitude of drilling contractors, toolpushers, drillers and roughnecks toward the program was found to be excellent. All answers to the question, "What tangible results do they feel that their company received from the training program?" were the same, and that was: "We certainly received a great deal from this program." But, when asked what exactly they received, the following were some of the replies:

The men have a "feeling of belonging."

We have the confidence of the men down to the lowest level.

The men know what is expected of them.

There is a feeling of pride in the company.

We have reduced costs.

We have reduced accidents.

The men have a better understanding of their responsibilities.

This program should have been started 24 years ago.

We have decreased insurance rates.

We have increased employe benefits.

We have increased our efficiency.

We have saved anywhere from $20 to $3000 per rig.

We feel that we are getting better men.

We now have a vacation plan.

We have saved $14,000 on claims.

We have better relations.

In analyzing these replies, it is found that the tangible results of this training program could be classified as follows:

Reduction of waste and spoilage.

Method and system improvement.

Reduction of labor turnover.

Reduction of learning time.

Reduction of supervisor's burden.

Reduction of equipment maintenance costs.

Encouragement of up-grading within the organization.

Reduction of accidents.

Improvement of communication.

Development and improvement of company relations.

Development of roughnecks' versatility.

Improvement of contractor-customer relations.

Reduction of grievances.

Improvement of morale.

It can be seen then, that this training program is proving to be of immense value to the drilling contractor, even though it is still in its infant stage.

In the training field it is said that there are three major responsibilities that every training director should be concerned with and that is, training in:

Knowledge of the company.

Skill in doing the job.

Proper attitude toward the work situation.

For the past century, the emphasis has been placed on skill in doing the job. However, today the main emphasis is being placed on the proper attitude toward the work situation, for once this proper attitude is attained, the job of training is simplified.

It was found that the training specialists of the University of Texas have that attitude and have passed that same attitude on to the men that they are training. It is this sort of thing that many training people have tried to achieve but have failed to do so. The University of Texas is doing a good job of training in the drilling industry.

Gulf Coast Hurricane Design Data

By A. H. GLENN
A. H. Glenn & Associates, New Orleans

THE engineer designing structures and equipment for service on the Gulf Coast must make allowance for the tremendous forces of the hurricane, which is capable of releasing energy over its destructive radius at the rate of approximately 2.5 atomic bombs per second.[1] In addition, his structure or equipment must function satisfactorily on one of nature's weakest foundations, the recent sediments of the Gulf Coast. These criteria present serious difficulties and proper design demands careful consideration of each. Many data sources and many techniques have been employed in estimating the magnitude of hurricane waves, winds, tides, and currents. Some are valid in the light of present understanding of Gulf hurricanes and others are erroneous in important respects. This paper discusses briefly the more important data sources and techniques, their limitations and advantages.

Considering first hurricane waves in the deep water, that is, in depths of roughly 500 feet or more (depths greater than one-half the wave length), there are only qualitative estimates as to wave height, and wave period. In a recent severe hurricane in the Atlantic (Sept. 6, 1950) which travelled slowly and developed wind speeds of about 150 miles per hour, a reconnaissance plane estimated waves of 100 feet in height (vertical distance from crest to trough). In severe non-tropical storms maximum waves have been reported from 70 to 100 feet in height.[2] It is reasonable to assume that waves in hurricanes can achieve heights comparable to those of other storms, so it is probable that severe hurricane waves attain heights of 70 feet, although the upper figure of 100 feet mentioned is questionable due to difficulties in estimation.

The ratio of height to wave length of breaking storm waves is approximately 1 to 13 so the length (horizontal distance from crest to crest) of 70-foot hurricane waves would be of the order of 900 feet. Since the wave length is approximately five times the wave period squared, the period of such waves (time between passage of successive crests) is of the order of 13 seconds. These data are only inferences that can be drawn from qualitative height estimates. At present we have no instrumental records of deep water wave height or period in hurricanes.

Consider next the height of hurricane waves in shallow water. As waves progress into the coastal zone they undergo transformation which ultimately results in the formation of breakers. The maximum height a breaker can attain is dependent on the depth of water at the point where it breaks. The maximum height of breakers resulting from steep storm waves is, to a close approximation, the still water depth divided by 1.7. This figure has been checked in wave tank studies and in actual observation and is believed to be sufficiently accurate for design. It should be mentioned that the still water depth must include the rise in water level caused by the storm tide. This point is discussed later.

It is fortunate that the relationship between maximum breaker height and depth is known because very few instrumental records of hurricane waves in shallow water are available. The U. S. Engineers[3] procured a number of wave gauge records in Lake Okeechobee, Florida, during the hurricane of August 26-27, 1949. These data give an indication of wave conditions in a protected lake or bay along the Gulf. Wave gauge records were also obtained from an oil drilling platform in 50 feet of water located about 6 miles south of Grand Isle, Louisiana, during the tropical storm of Sept. 3-4, 1949. These are indicative of conditions at intermediate depths on the continental shelf. These records are all that are now available which bear on Gulf Coast problems and neither was obtained under severe hurricane conditions.

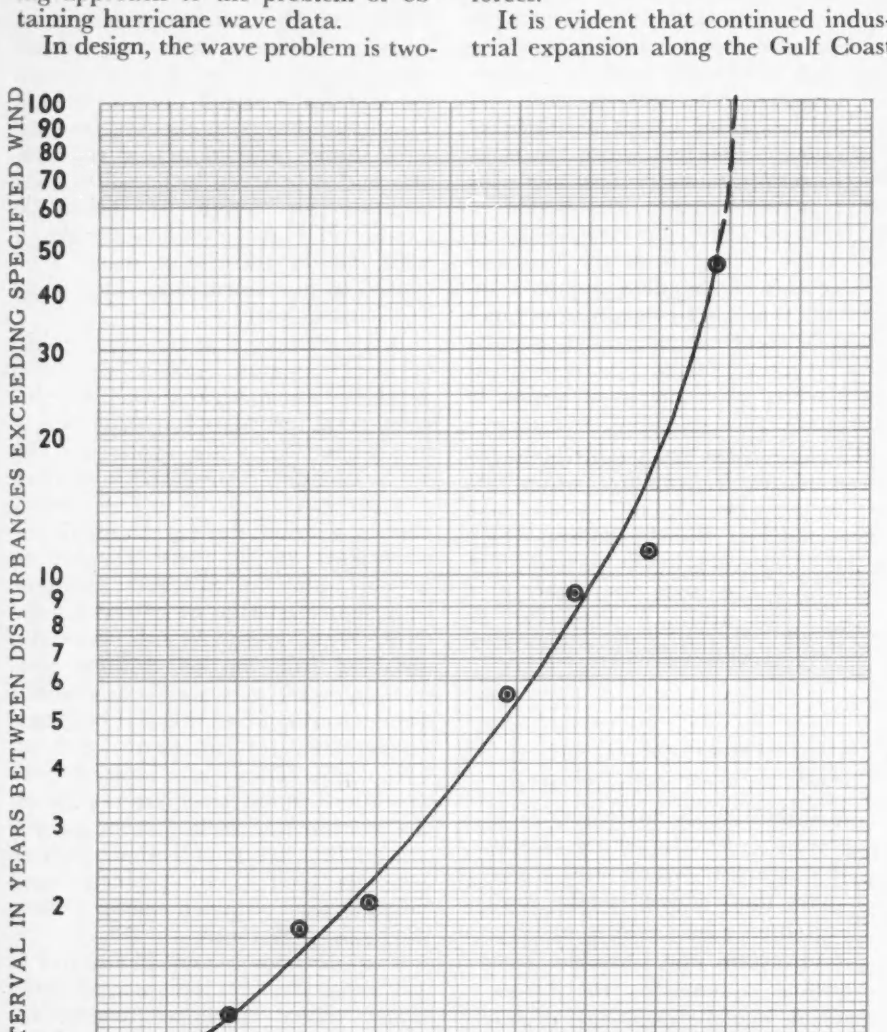
Two methods present themselves as possibilities for obtaining wave records under severe hurricane conditions. First, recording wave gauges can be installed at various locations in the hope that they will be subjected to severe hurricane action at some later date. This method has the disadvantage that it may be many years before the desired record is procured, and also there is a possibility that the gauge may be inoperative at the critical time. Second, use may be made

METEOROLOGICAL research on wind and wave action in full-strength hurricanes is a necessary forerunner of design of a structure which must withstand those forces while supported on a base which, at best, is uncertain and unstable. The author summarizes the forces which may be expected, evaluates storm tides and their possible maximum effect, and traces the influence of hurricane tides on normal flow in coastal areas. The paper was presented before the annual meeting of the Petroleum Division, ASME in New Orleans.

of the Airborne Swell Recorder[4] developed by the British Admiralty. This device is a sensitive radio altimeter which continuously records wave height within an accuracy of a foot when carried by aircraft flying at an altitude of 150 feet. Reconnaissance aircraft now customarily fly at altitudes of 400 to 600 feet through hurricanes and it is believed that wave records obtained from the many sorties these planes fly annually would provide the wave records desired within a few years and within the desired order of accuracy of several feet. Inauguration of a program to obtain such records would require the cooperation of the Office of Naval Research, the Air Force Research and Development Branch and the respective operational groups involved. At present this seems the most promising approach to the problem of obtaining hurricane wave data.

In design, the wave problem is twofold. The structure must be high enough to prevent wave action extending to equipment and machinery, and strong enough to avoid failure of those portions of the structure which are necessarily subject to wave action. Many theories regarding wave forces have been used.[5,6] They give quite different results when applied.[7] At the time offshore drilling platforms were first designed the technique developed by Munk[8] was employed as embodying the latest research concerning wave action. In recent model studies Morison[9] indicates that Munk's technique requires modification to allow for acceleration forces which develop in waves. At present none of the methods proposed for calculation of wave forces is entirely satisfactory and there are relatively few field measurements of wave forces.

It is evident that continued industrial expansion along the Gulf Coast will demand development of an acceptable theory of wave forces. Field measurements, model studies in wave tanks, and the extension of theoretical research will be required.



Frequency of tropical disturbances exceeding specified sustained winds within 150 miles of Burrwood, La. Chart based on analysis of Tannehill's 44-year record of disturbance tracks. (Graph shown to illustrate technique. Not suitable for design purposes.)

Most of the hurricane damage to coastal property is caused by the storm tide, frequently incorrectly called "the tidal wave," and the currents associated with it. The mechanism of the tide is not entirely understood, but apparently five factors contribute to its rise:

- The lowering of atmospheric pressure in the center of the hurricane. This decrease in pressure of one to 3½ inches of mercury below surrounding atmospheric pressure maintains a head of water in the hurricane center one to 2½ feet above surrounding water level.
- The effect of wind action in the hurricane directed towards the shore maintains a "slope" on the water surface. This is first noticeable as a rise in tide along the Gulf Coast before hurricane winds affect the coast. The rise varies from a fraction of a foot to several feet. In the Galveston hurricane of 1900, the tide reached five feet above mean low water before winds exceeded 20 mph.[10] The slope is then increased when hurricane winds affect the location.
- The effect of strong winds in producing ocean currents. The wind over shallow water raised by the storm tide on the coast will produce a current moving in approximately the same direction as the wind.[11] The speed of this current depends on the speed of the wind and as this current impinges on obstructions there will be local "damming" which effectively raises the storm tide. The speed of these currents has not been accurately reported but is unusually high and undoubtedly depends to a great extent on local constrictions in the flow.
- The effect of breaker action in moving water onto the coast. There are many observations of the extremely high breakers driven onshore during hurricanes. In addition to the breakers there are a number of observations of "bores" during hurricanes.[12] A bore is a wave of translation or "wall of water" several feet high which resembles a breaker except that the water level does not return to normal after the passage of the bore.
- The effect of a small but continuous drift of water onshore by the displacement of the water molecules forward in the direction of wave movement. In shallow water, the water molecules describe an orbit in the form of an ellipse in a vertical plane oriented in the direction of wave motion. The elliptical orbit is

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not perfect, such that after the passage of a wave crest the water molecules are displaced a short distance ahead (in the direction of wave motion) of their previous positions. This phenomenon accounts for a piling up of water along the beach.

Tide gauges maintained by the U. S. Coast and Geodetic Survey and the U. S. Engineers on the Gulf Coast provide the principal source of data concerning storm tides. Study of the U. S. C. and G. S. data indicates the maximum storm tide yet recorded on the Gulf was 11.8 feet at Galveston in the August, 1900 hurricane. Other sources give values as high as 16 feet but these can not be verified by inspection of the original records and must be taken with reservation.

With the exception of records obtained from one tide gauge now in operation on an offshore oil production platform, there are no data available concerning the height of storm tides in the open Gulf. When offshore platforms were designed for offshore oil operators it was assumed that the extreme storm tides of approximately 12 feet which have been observed on the coast resulted from damming of the water as it moved onto the land and could not occur in the open Gulf. However, during the tropical storm of Sept. 3-4, 1949, the storm tide six miles south of Grand Isle, Louisiana, was of about the same order of magnitude (three to four feet) as that observed at the Grand Isle tide gauge (Bayou Rigaud). This casts some doubt on the original design assumption that a five-foot storm tide is the maximum which can occur offshore away from the frictional effect of the coastline. Additional tide data will be necessary before an estimate of offshore storm tides can be made. This is quite important because the height to which wave action extends depends on the tidal level. Apparently the way to obtain these data would be installation of tide gauges on other offshore structures, or damped pressure gauges on the Gulf bottom. At present the only safe assumption is that ten-foot storm tides can occur in the open Gulf.

The magnitude of the currents caused by hurricane winds over the open Gulf and by movement of the storm tide on the coast is not known. Obviously, extremely strong currents occur since major changes in the topography of the Gulf Coast have resulted from these currents and heavy objects have been carried long distances by current action. Attempts to calculate the speed of such currents by hydraulic formulae lead to questionable assumptions or an indeterminant problem. The difficulty in measuring currents under hurricane conditions or even procuring satisfactory current meters for measurements under any conditions leads one to believe that the data will be difficult to obtain. At present, currents of five to six knots appear possible at exposed locations on the coast, and local constrictions in the flow may raise them above these values.

Hurricane Winds

Extensive data on winds in hurricanes are available through a number of sources, the most reliable of which in this country are the U. S. Weather Bureau, the Navy Aerological Service, and the Air Weather Service. In obtaining design data it is advisable to search the original records rather than depend on second-hand published accounts. The value of 125 mph is quite frequently used as a design criterion and while this is a good estimate of sustained winds in a severe hurricane, it is by no means the maximum speed which hurricane winds can reach. Anemometers and the conventional power supplies and mountings now in use usually fail at wind speeds in the vicinity of 125 mph so that information on instantaneous gust velocities in severe hurricanes is sparse and sketchy. Hurricane maximum gusts are about 50 percent greater than sustained winds measured over intervals of several minutes. Maximum gusts in the vicinity of 185 mph have been recorded in hurricanes.

Standard formulae for calculating wind speeds from pressure gradients have been employed[13] from time to time to determine hurricane wind speeds when pressure data were available in the storm area and wind data were not. This is not a reliable method because the instantaneous pressure field around a hurricane can rarely be determined, and in any case the standard wind-pressure gradient equations apply only to a wind field in which acceleration is zero, a condition which is not fulfilled in hurricanes.

Since it is known that maximum wind speeds of 185 mph, maximum storm tides of 12 feet, and corresponding high waves and currents can occur in the most severe hurricanes it is evident that most of the structures along the Gulf area are not designed to weather the worst possible hurricane without damage.

Such a maximum possible hurricane can be expected to occur so rarely, however, and the chance that it will strike a particular location is so small that it is customary to under-design for a hurricane of lesser proportions which has a reasonable chance of striking the installation within its useful life. Such an under-design should be based on first, a selection of the hurricane which has a reasonable chance of hitting the structure (Figure 1) and second on estimates of the maximum wind, tide, current, and wave conditions such a hurricane can cause as determined from the best data sources and theoretical techniques. Care should be taken to avoid a design which, for example, will withstand a 125 mph wind, but would not withstand the storm tides caused by a 125 mph wind.

The hurricane design data now available and the experience with certain types of structures and equipment in hurricanes when properly interpreted in terms of the best features of existing theory provide a means of arriving at hurricane design criteria which is a great improvement over the guess work of earlier years. There are serious gaps in existing data and theory and continued industrial expansion on the Gulf Coast will demand that these gaps be eliminated. It is believed that a concerted, cooperative effort by and for Gulf Coast industry to acquire the necessary design data would achieve the desired results in a period of five to ten years. If such a program is inaugurated it will be important that the research be under the administrating supervision of persons interested in and responsible to Gulf Coast industry. Present wave research is primarily aimed at the solution of theoretical problems or the solution of practical problems pertaining to coasts other than the Gulf. The value of such research in solving problems on the Gulf Coast will be a by-product of its principal objective. Since the problems of the Gulf Coast are unique, meteorological and oceanographically speaking, effort must be directed towards their particular solution.

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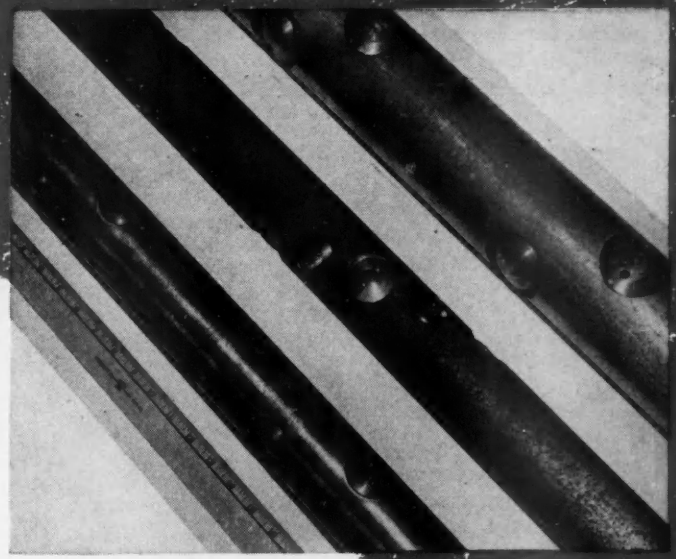
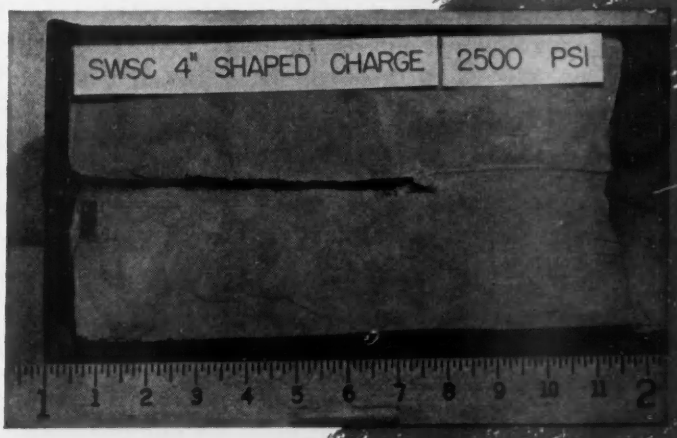


2⅝" carrier, left, 4 shots to the foot; 2⅝" carrier, center, 6 shots to the foot; and 4" carrier, right, 4 shots to the foot.



Fire power is graphically illustrated by this cutaway test block.

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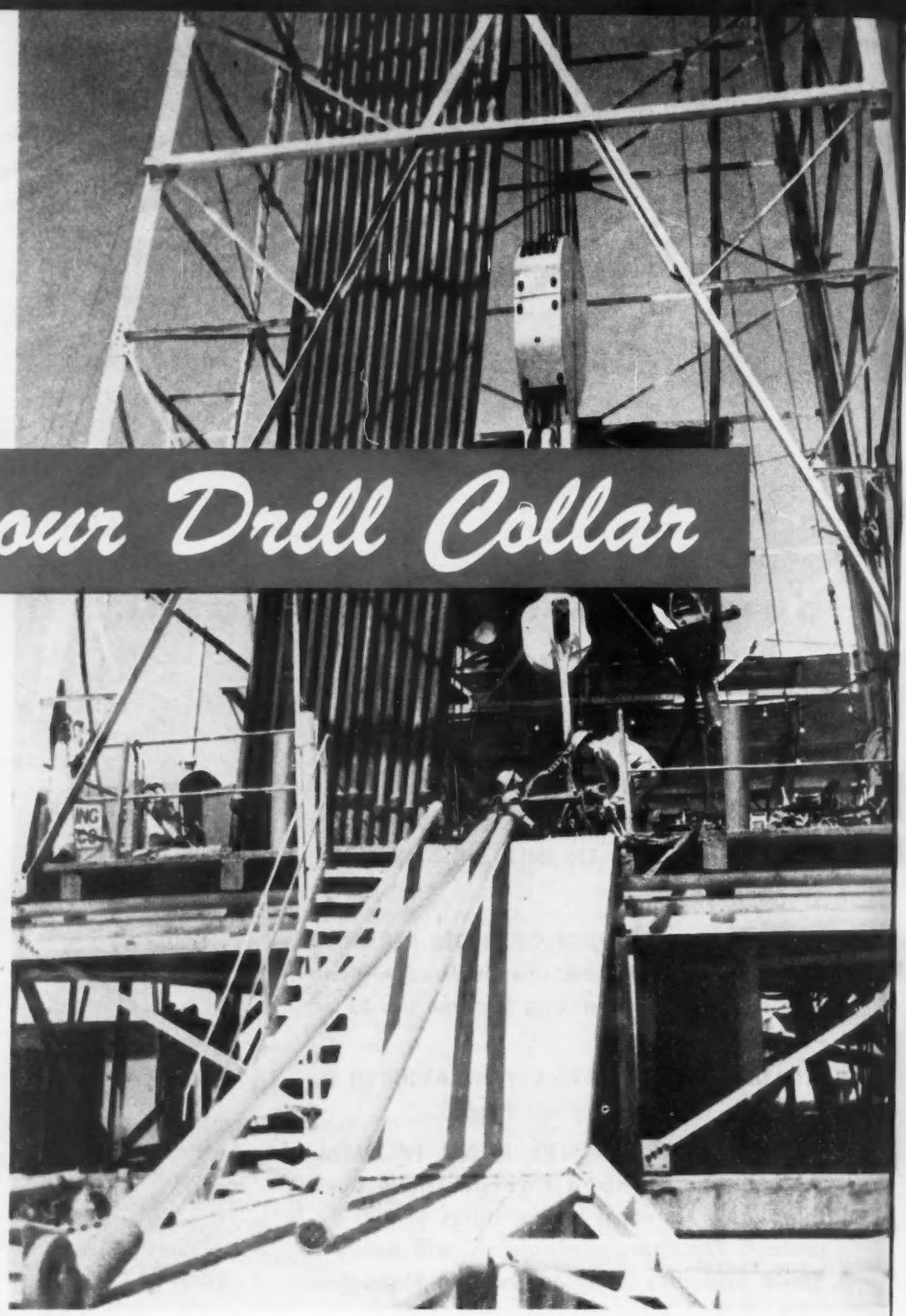


THE AUTHOR describes material and treatment factors which may seriously affect the service performance of drill collars. Although the technical terms are those common to metallurgy, their use is such that their application is clear to the man at the rig. The illustrations clearly depict the relationship between suggested cause and collar performance.

THE increasing quest for oil at greater depths and the necessity of drilling the holes at more efficiency has made the drill collar one of the most expensive items to the contractor. The trend has been the gradual increase to multiple strings for the purpose of concentrating the required weight and a rigid column directly above the bit for faster and straighter holes. Now with possible scarcity of alloy steels the oil field operating personnel should be trained to prolong drill collar life by careful handling.

In the past, only two or three drill collars were used in a string; therefore there was little necessity for perfect heat-treated steels and careful handling. Now with multiple strings the drill collar must be well balanced from end to end and internal structure must be uniform and free of stresses. The failures, mainly in the thread connections, have increased to the point that the manufacturer has gone to great expense to manufacture a near perfect drill collar. Although failures have decreased considerably at present, there are many that are caused mainly by mechanical abuse, such as improper torque, cross threading, dirty grease, etc., and last but not least, mishandling. There are also too many failures due to the incorrect selection of efficient hardening steels, inefficient heat treatment, and also failures due to defective steel. However, the writer believes the majority of the failures are due to mechanical abuse by transportation and in the field, also possible selection of incorrect thread connections in regard to the outside and inside diameter sizes, on what is otherwise a well balanced pin and box connection with the body mass of the drill collar.

Since this discussion will dwell

By TREBOR B. MORRIS

Chief Metallurgist, American Iron & Machine Works Company, Oklahoma City

mainly on the metallurgical problems, only a few examples of mechanical abuse are named that will probably cause failures in multiple drill collar strings. These failures occur in the thread areas, which three examples of fatigue failures are caused by the following discrepancies, or handling that will cause defects in the drill collar: (1) transporting on winch truck by winching drill collar down between the head post and tail board, in which the vibrations cause stress concentrations at the supported ends—thus permanent "kinks" are formed and breakage occurs; (2) cross threading by angling top collar when mating pin into the box connection and thus causing galling; and (3) loose shouldering when mating connections which causes fatigue and galling. Photographs of two representative failures of cross threading and loose shoulder makeup are shown in Figure 1.

Considering that the metallurgical factors are correct, there are other important factors necessary to manufacture a perfect drill collar:

1. No short bends in original bar.
2. Perfect alignment after machine OD.
3. Straight bore with no shoulders and concentric with OD.
4. Hobbed threads in place of single pointing.
5. Taper, profile, length, depth, and thread gauging must be held to the API specification.
6. Smooth shoulder faces at right angles to C/L of thread connection.
7. Thread treatment to retard metal seizing during the breaking-in period.

The alignment (2) and (3) smooth bores concentric with the OD have become vital factors in multiple strings. The general opinion is that an unbalanced or crooked drill collar results in stress concentrations at the jointed connections. A good description is that by John B. Coulter,[2] "These stress concentrations probably are caused by transverse vibrations or sine waves. As these waves move through the drill collar string, they are thought to change in frequency and even reverse themselves." If these vibrations are suddenly reversed, there would be a comparative impact shock at the jointed connection. The vibrations in conjunction with compression loading, reversals, shear, tension, and actual impact would cause a failure and especially in drill collars with low impact (Izod) strengths.

Now that we know there are a multitude of possible mechanical errors that will cause the thread connections to fail, it is evident that the steel must be in good condition to withstand the natural abuses. The deficiencies in the metal in relationship to the drill collar failure shall now be discussed in a non-technical manner.

It has been found (from comparing hundreds of failures) that certain defects in the steel will usually cause drill collar failure in multiple strings

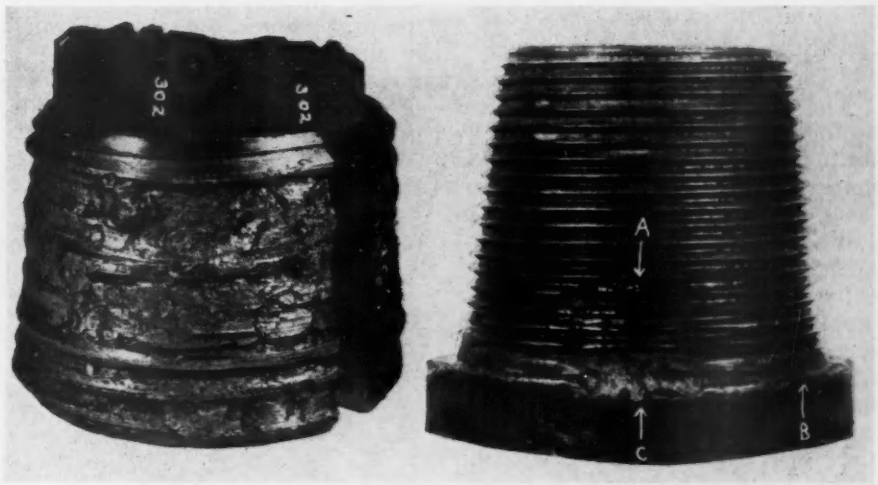
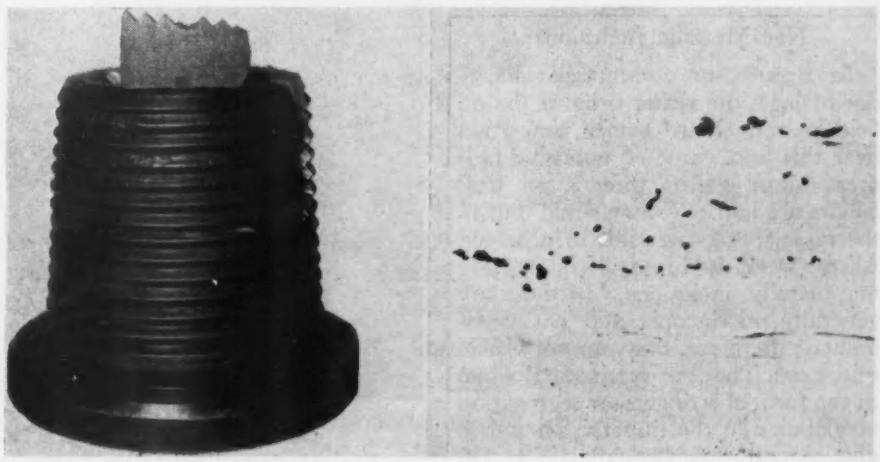


FIGURE 1. (Left) Cross threaded when mating male and female. (Right) Loose shouldering (improper makeup) allowed "wobble" and fatigue break at A which washed at C.



Flaked threads. FIGURE 2. Slag segregation on threads.

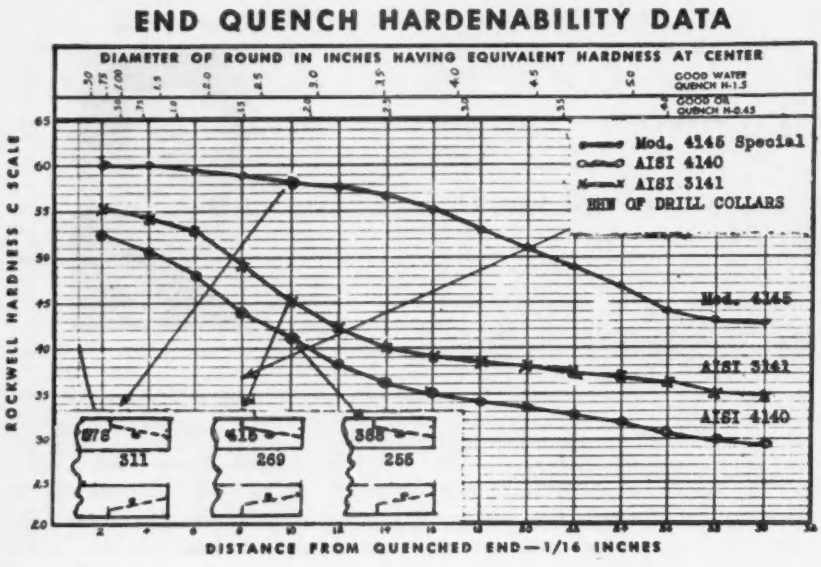


FIGURE 3. Comparison of the low hardenability of three steels and hardness results one inch below the surface.

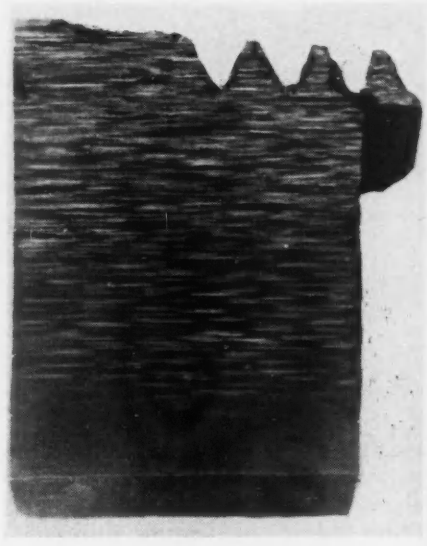


FIGURE 4. Insufficient alloys and hardening characteristics for depth hardening uniformly.

and sometimes in all uses, which the most common are listed:

1. Cracks at joint connections.
2. Excessive non-metallic inclusions (slag) in threaded areas.
3. Stressed structures due to non-uniform structures.
4. Brinell hardness out of range.

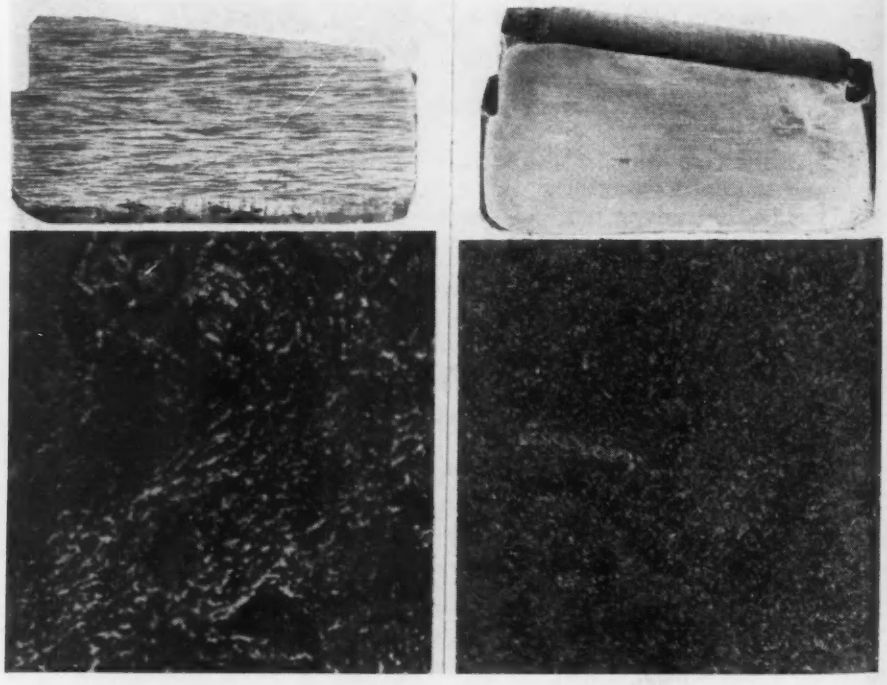
The majority of the cracks caused by forging, rolling, and sometimes by heat treatment will usually extend longitudinally along the drill collar. These cracks are often formed in seams and laps, and during heat treatment will grow in depth. Circumferential cracks at the thread area are usually caused during the oil quenching. These cracks must not be confused with fatigue cracks that originate during use. Occasionally drill collars with dangerous cracks may find their way into the field, but this should be rare, since many operations and inspections are required before completion and the cracks are generally detected.

Non-Metallic Inclusions

In regards to non-metallic inclusions (slag), the writer believes the oil field personnel are overly concerned over this as a cause of excessive failures. Many galled threads on drill collars are laid to "dirty steel," but in the majority of cases this is incorrect. All the steels used in drill collars have non-metallic inclusions, but these are generally microscopic and not detrimental; therefore, they are not visible to the eye. They are detrimental when in the form of stringers, or segregation of globules on the threads. They usually extend longitudinally with the grain of the steel and usually cause the threads to gall and not break. The stringer type and excessively enlarged globules are usually detected by the machine operator, because the steel burnishes and dulls the cutting tool. However, the cleanliness of the steel is held under rigid specification and the steel manufacturers are thorough in their inspection. An example of thread flaking on a drill collar due to segregation of slag is shown in Figure 2.

Non-Uniform Structures

The meaning of non-uniform structure is a combination of different constituents that result from various alloys in the steel and conditions in the heat treatment. The majority of the non-uniform structures in the drill collars consist mainly of tempered martensite with ferrite scattered throughout and usually with fine particles of carbides. Low temperatures are required to retain the surface hardness within the specified range. Such structures are in stress and results in low impact strengths. There are controversial opinions among the oil field personnel as to whether low Izod will cause failure. Some are of the opinion that the failures are due to fatigue, in



(A) "As Received" broken drill collar. Inefficient heat treatment.

FIGURE 5.

(B) After treatment, a uniform structure and hardness resulted.

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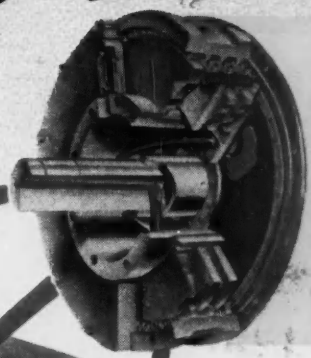

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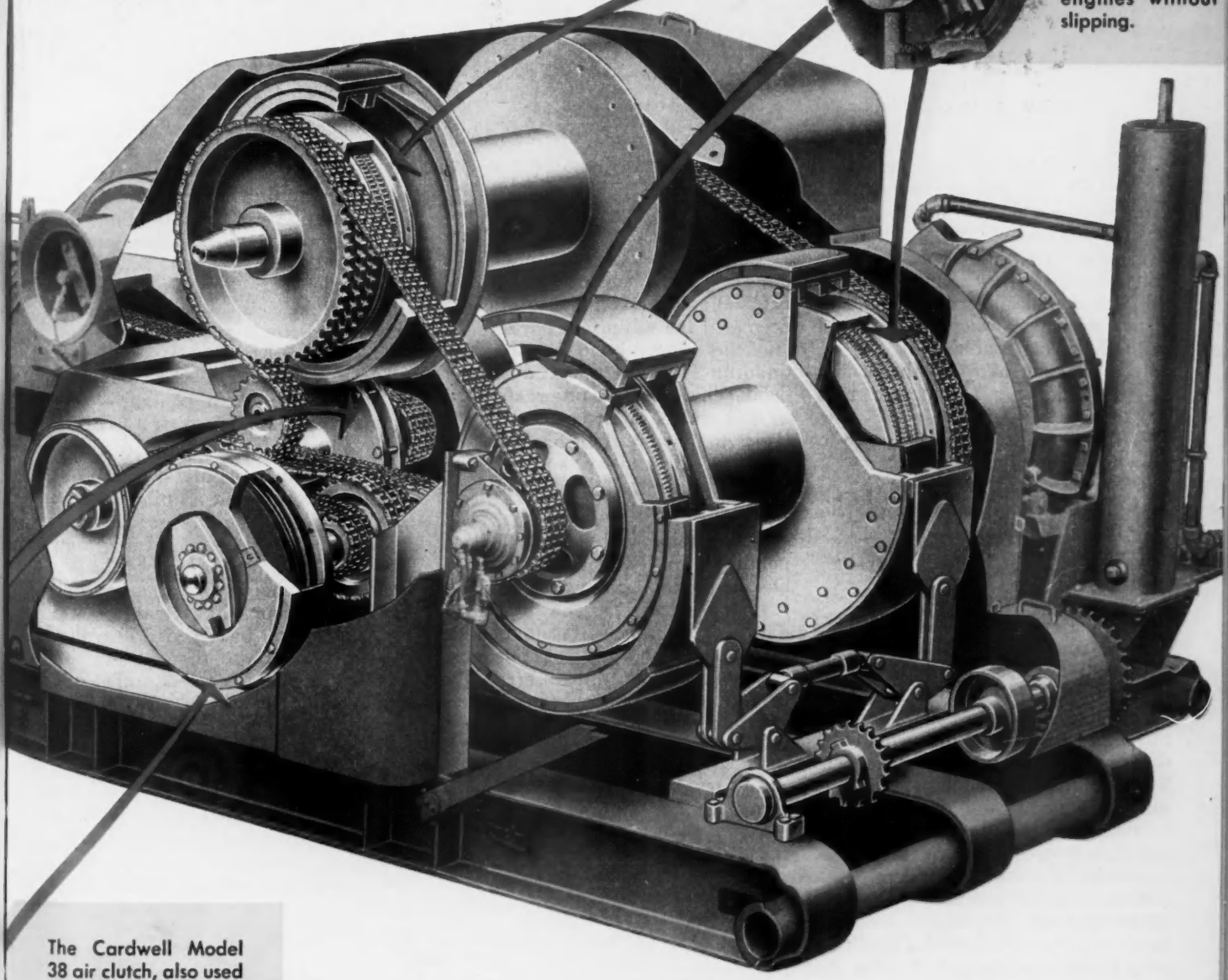

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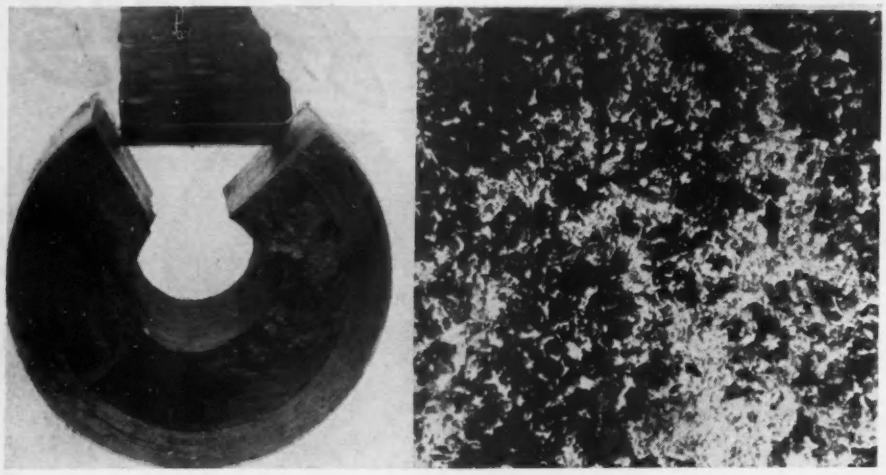


FIGURE 6. Air cooled drill collar. Low impact of seven foot-pounds.

which impact has no relationship to fatigue. Others believe low impact structures have high residual stresses which will lower the fatigue strength. Regardless of the different opinions, drill collars with low impact strength will fail in multiple strings. The low impact structures are generally caused by the following conditions:

1. Insufficient alloys, or hardening characteristics for depth hardening.
2. Insufficient soaking, or not up to heat when quenching.
3. Slow cooling rate due to insufficient oil agitation, sludgy, or inferior quenching oils.
4. Air cooling in place of oil.

Insufficient Alloys

The majority of the drill collars used are the six-inch OD and larger with wall thicknesses averaging 1⅞-inch and thicker. This means the steel should have hardening characteristics to harden thoroughly throughout the wall thickness during the oil quench. The Jominy hardenability test determines the depth and distribution of hardness induced by quenching. Various alloys improve the hardening characteristics of the steel for depth hardening such as manganese, chrome, nickel, molybdenum, etc. Therefore, a hardenability test made on a duplicate steel to that used in a drill collar determines the subsurface hardness that can be expected when the collar is heat treated. The hardenability chart in Figure 3 compares the hardness curves of the modified 4145 special, AISI 4140, and AISI 3141 steels, which were all in the low range.

Tests of 6½- x 2¼-inch drill collars from the same steels, as shown on the hardenability chart, were oil quenched. and specimens taken showed the following results. The hardness values at one inch below the surface of the 3141 and 4140 steels were considerably lower than that of the Modified 4145 steel. Since the two collars did not harden thoroughly in the subsurface or on the surface, a low (850° F. and 900° F.) temper was required to retain the surface hardness near the 300 BHN aim. However, the low temper decreased the subsurface hardness below the range, besides being non-uniform. Therefore the alloys, or hardening characteristics of any steel used in drill collars, must be controlled in order to acquire full hardness and structure. The alloy and resultant hardnesses of the three collars are shown in Table 1.

A drill collar with a low (12.0 foot pounds) impact strength failed at the box connection, as shown in Figure 4. A macro etched reveals a uniform dark area from the surface to one-half inch below with a banded appearance extending to the thread area. This condition represents an efficient cooling rate in the quench, but due to inefficient hardenability (alloys) in the steel the subsurface failed to harden uniformly. This type of structure is brittle and subject to galling or breakage at the thread area, depending whether in short or multiple strings.

The question of inefficient heat treatment, regardless of the alloy content, will result in non-uniform hardness and structures from surface to bore. This can be eliminated if the following important conditions are guarded against:

1. Furnace hardening temperature is below 1550° F.
2. Cold spots in furnaces, or near door.
3. Not leaving drill collars in furnace for soak at temperature.
4. Quenching in slow moving oil.
5. Sludgy oils have slow cooling rate.

The condition of inefficient heat treating is represented by a macro etched section and respective microstructure of a drill collar failure shown in Figure 5A. After retreating the large sample, another macro etched section and structure is shown in Figure 5B. The non-uniform structure (banded appearance was caused by one or a combination of the above factors. This drill collar had sufficient alloys, but the poor heat treament resulted in a 16.5 foot pounds impact strength with a hardness of 311 BHN.

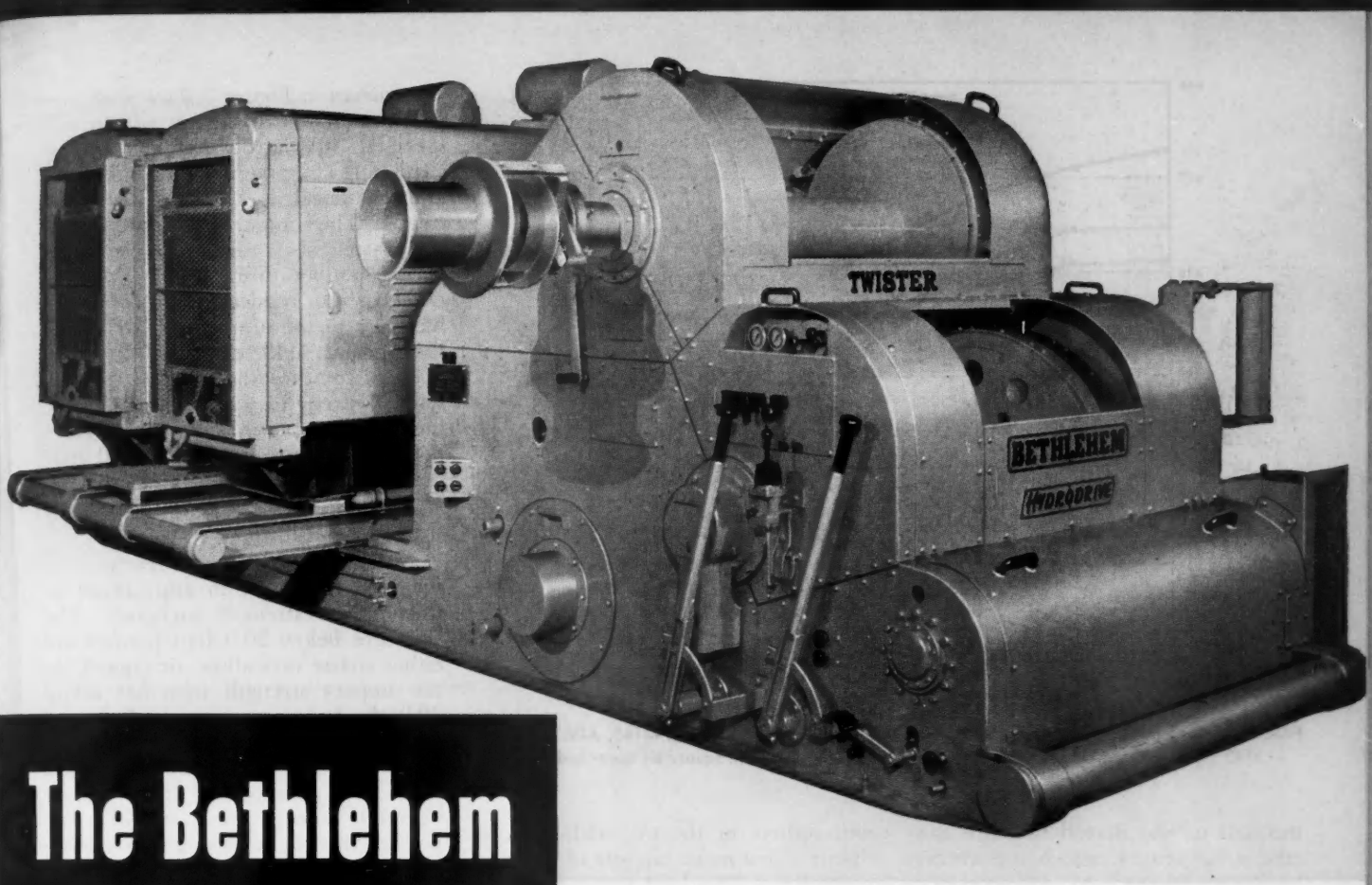
The air hardened drill collar no doubt gained unpopular fame in recent years, due to the multiple failures in multiple strings. These over-all hardened drill collars came into prominent use during the last war, when there was a shortage of oil quenching facilities to supply the great demand for the over-all hardened drill collar. At the time it was thought that increasing the alloy content sufficiently and cooling by air in place of oil would harden the bars sufficiently. The air did harden the surface sufficiently for a low temper treatment to reduce the hardness to the regular range. However, a simple explanation of what happened was that micro-segregations of hard and soft spots throughout the wall area resulted and

TABLE 1

Type of Steel	PERCENT ALLOY CONTENT				
	Carbon	Manganese	Chrome	Nickel	Molybdenum
Modified 4145	.43	91	.93	....	.26
AISI 4140	.38	.74	.90	....	.17
AISI 3141	.40	.81	.85	1.19	....

Type of Steel	Temper °F.	BRINELL HARDNESS			
		After Quench		After Tempering	
		Surface	1" Below	Surface	1" Below
Mod. 4145	1020	514	495	302	293
AISI 3140	850*	388	375	285	255
AISI 3141	900*	415	388	293	262

* Low temper necessary to retain the surface hardness near the 300 Brinell aim.



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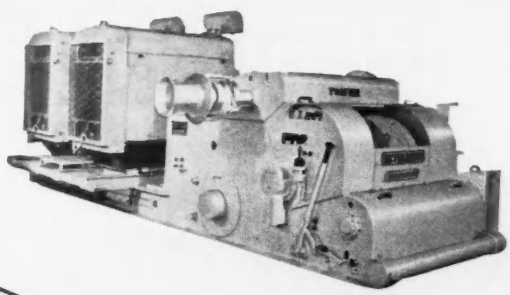

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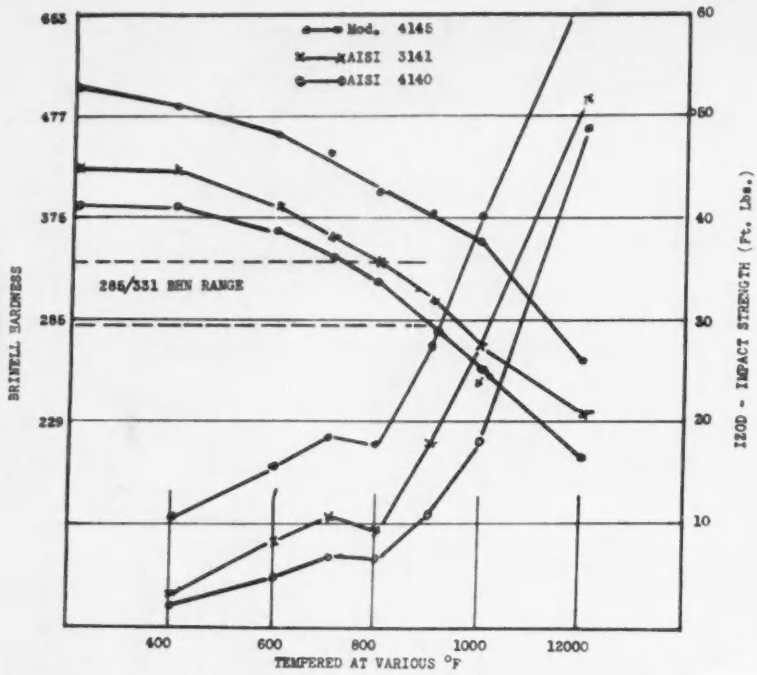

FIGURE 7. Comparing impact strength of low hardenability steel from Mod. 4145, AISI 3141, and 4140. Hardness and izod results represent the center of two-inch square oil quenched bars.

the ball of the Brinell machine covered a large area, which the average hardness resulted at approximately 300 BHN. Actually, the hard spots were considerably above and the soft below 300 BHN. This variation in the structure proved to be highly stressed and brittle. Drill collars of this type failed in both the foreign and domestic fields. The remedy for these bars was to reheat and oil quench, which a very tough structure resulted. A representative air hardened drill collar failure and its respective structure are shown in Figure 6. The writer believes the failure of this type of collar proved the value and importance of the Izod test.

The Izod has become an important factor to some people and as a joke with others in the oil field, such as "pour a few more buckets of Izods in the collar." The Izod test is a pendelum type of impact in which the specimen is supported at one end with the pendulum hitting the free end to determine the energy absorbed in fracturing. The hard steel requires little energy to break and an extremely soft or sorbitic structure of 300 BHN requires considerable energy, due to brittleness in one and toughness in the other. Therefore, the drill collars are heat treated to the best range of tensile plus toughness. Since the tensile strength is related to hardness and the ductility to impact, then at approximately 300 Brinell hardness the two should be at maximum, providing the steel and heat treatment are correct.

The curves in Figure 7 show that impact and tensile will cross within the specified 300 hardness range if the hardening characteristics are sufficient and the steel is thoroughly heat treated. The comparative results of the three steels show that a higher tempering temperature (1020° F.) was necessary to reduce the quenched hardness to the aim of 300 BHN for the Special 4145, than the 850 and 900° F. for the other two steels. The impact strength was considerably higher at approximately 45.0 foot pounds in comparison with 16.0 foot pounds and 8.0 foot pounds for the AISI 3141 and 4140 at approximately the same hardness.

It has been found that fractures of the Izod bars vary in appearance as the impact strength increases. The fractures below 20.0 foot pounds are either coarse crystalline, or jagged. As the impact strength increases above 20.0, the grain appearance is finer and a cup progressively increases. A definite cup appears at approximately 30.0 foot pounds and the fracture begins to smooth out. Near 40.0 foot pounds the cut is deep and a smooth dark fracture appears, which represents high ductility. The photograph, Figure 8, shows five fractures at 302 BHN hardness that are approximately representative at their respective foot pounds strength.

Although this discussion has dwelled mainly on the defects in the steel and heat treatment, it is firmly believed that the drill collar failures would decrease considerably if the transporters and operating personnel carefully handled the collars, thus lengthening the life of the collar with a considerable saving to all concerned.

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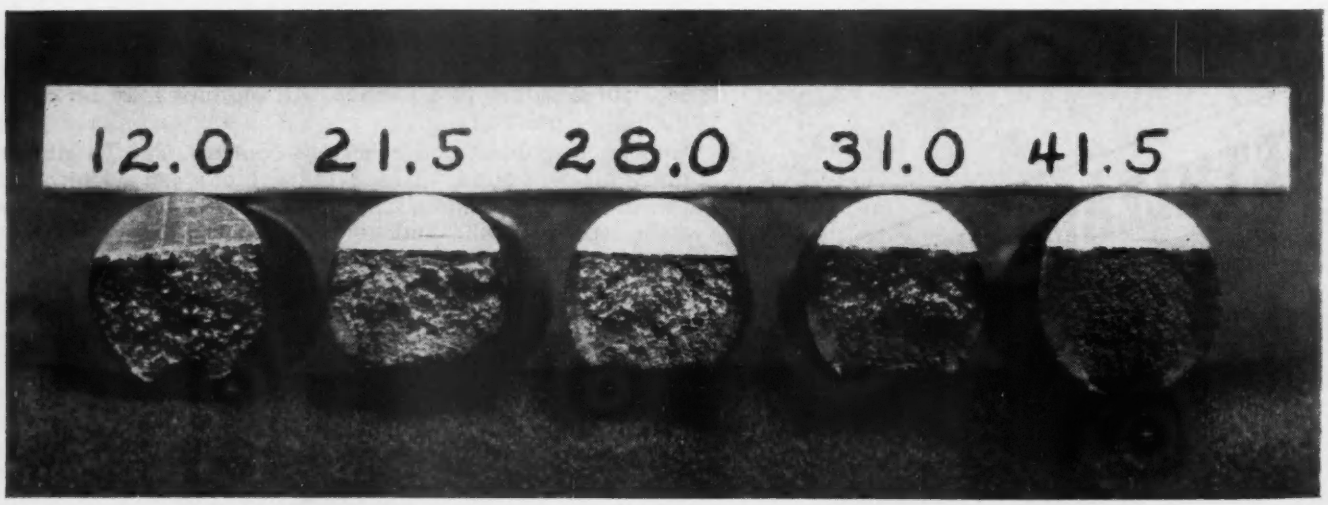

FIGURE 8. Comparative Izod fractures from low to high foot pounds, or inefficient to efficient heat treatment.

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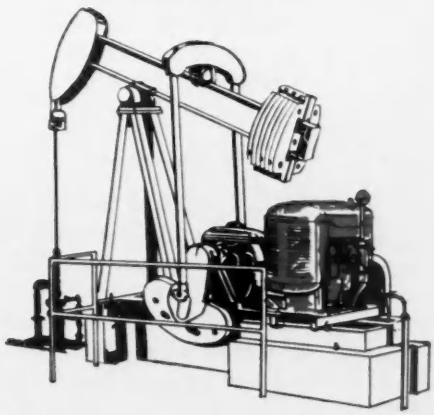

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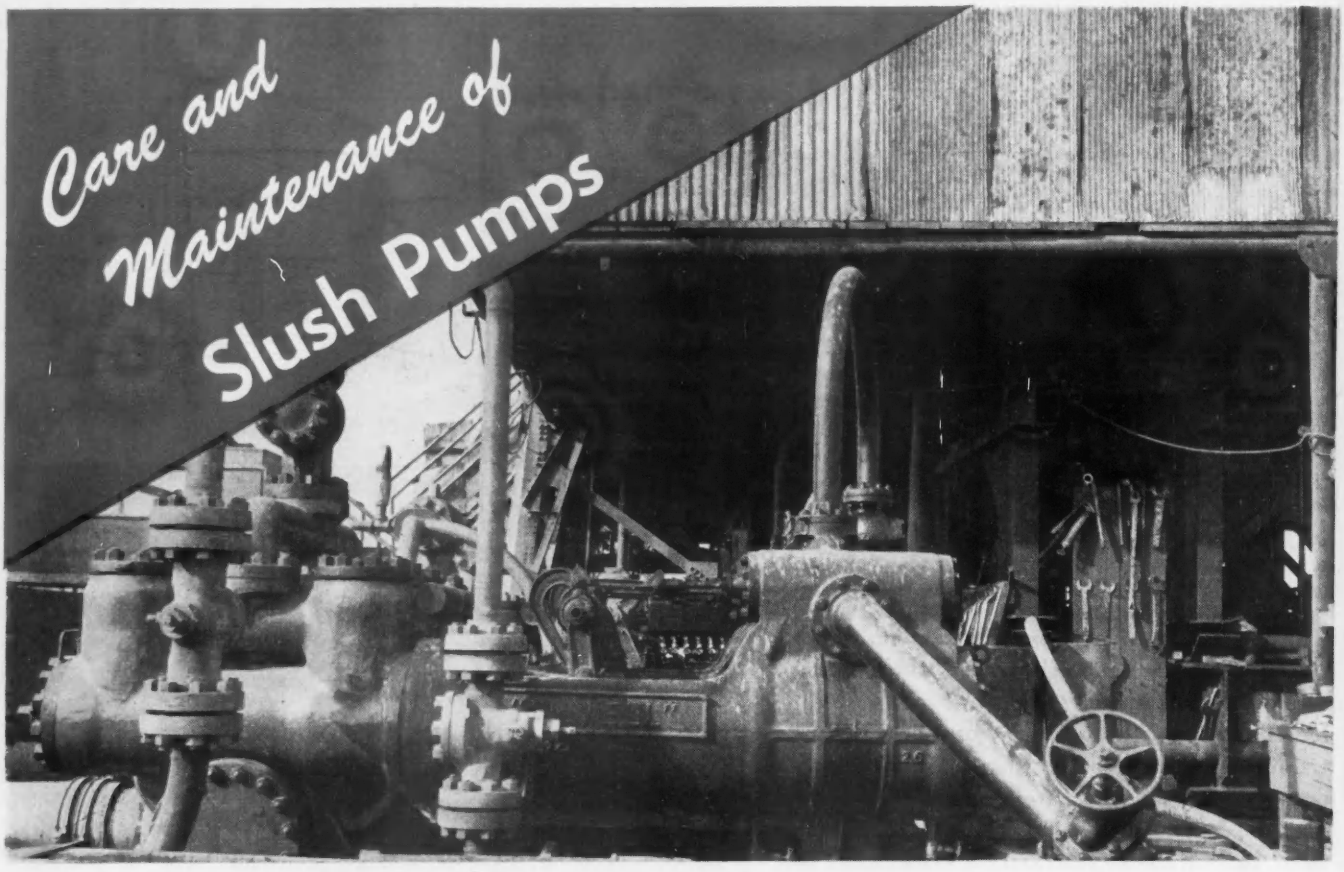
Care and Maintenance of Slush Pumps



By W. J. REDMAN
Chief Engineer, Wilson-Snyder Manufacturing Division,
Oil Well Supply Company, Braddock, Penn.

MUCH has been said and written about how to select suitable pumps and prime movers for oil well drilling. There is no mystery about the many factors which determine the mud volume and pressure required. The main consideration is that the equipment selected shall be neither too small nor too large for the contemplated drilling operations. If it is too small, parts will be overstressed and bearings will be overloaded, decreasing their life. It will be a constant burden to the owner, requiring frequent expenditures of money for parts and service to keep it in operation. If it is too large, it is heavier and more expensive to move and represents excessive capital investment, which handicaps the operator in trying to get work for the rig since higher rates must be charged. A well balanced rig soon demonstrates its ability and attracts business to its owner. Sales organizations are always ready and willing to recommend suitably sized equipment.

Neglected or abused equipment is liable to fail at a critical time and sometimes causes loss of the hole. On the other hand, a program of periodical inspection and maintenance will keep equipment in shape to meet the emergencies which are encountered in drilling. Such a program is called "Preventive Maintenance." Its purpose is to discover and replace worn or badly damaged parts resulting from previous operations and to make sure that all parts are properly adjusted and tightened. Time and effort spent in carrying out this program will be repaid in reducing the amount of down time necessary to repair failures after they occur.

A program of preventive maintenance in regard to pumps may be said to begin with the use of correct liner sizes for the pressures encountered. Changes in liner sizes must be kept to a minimum but there is a natural tendency to put off changing to a smaller size as long as possible without stalling the drive. It is obvious that such practice overloads the pump, the prime mover, and the drive for a considerable part of the operating time. Pumps are designed to have a conservative life based on specific loading and have ample safety factor to carry considerable overload for short periods.

Constant overload shortens the life of a pump by causing rapid wear and fatigue of working parts. Considering only the bearings used in a pump, a constant overload of only 10 percent would reduce the expected life more than 25 percent, and a constant overload of 25 percent means a re-

THE PRINCIPAL causes for mud pump failure are traced, and recommendations given to avoid the faults in operation which lie behind the failures. The author summarizes the 20 factors which enter into pump life and performance, listing them for easy reference by the man in the doghouse. The paper is substantially as presented before the 10th Annual Meeting of the American Association of Oil Well Drilling Contractors at Tulsa.

duction of about 60 percent in bearing life expectancy. To illustrate this graphically, Figure 1 shows the effect of loading on bearing life and pump speed. If a minimum bearing life of 20,000 hours at 50 revolutions per minute pump speed is taken as 100 percent loading, the chart shows that 109 percent loading, or less than 10 percent overload, decreases the bearing life to 15,000 hours or a loss of 25 percent. A loading of 89 percent, or 11 percent less than full rating, increases the bearing life to 30,000 hours or a gain of 50 percent. The chart also shows that, keeping the same minimum bearing life, the amount of permissible loading is greater as pump speed decreases and is less as pump speed increases. On this basis, overloads at low pump speeds are not as harmful as those at higher speeds. It is easy to understand from these figures that overloading a pump for long periods will require earlier and more frequent replacement of worn parts. Liner sizes should be changed as necessary to keep within the manufacturer's rating for the pump.

Pressure relief valves set to suit the liner pressure are intended to protect the pump against damage. In general, a satisfactory setting is about 50 percent above the recommended pressure for the liner size being used. When liners are changed to smaller size, the set pressure is increased by using a larger nail. When the larger liners are again installed, it is important to make sure that the nail size also is changed to suit. Never use a piece of welding rod in the relief valve. They were not designed to operate on that basis, and, in fact, it has practically the same effect as having no relief valve at all. Relief valves cannot give the protection expected of them unless used in accordance with the manufacturer's recommendations as stated on the name plate.

Pump liners, liner packing, pistons, piston rods, piston rod packing, valves and seats are expendable items. They have relatively short life because extrusion of the rubber parts and the abrasive action of the mud and sand cause rapid wear. Constant research is being conducted to improve these parts and increase their service life. It is false economy to try to use them beyond the time when they should be discarded.

Liners which have scored or pitted bores will tear up the fluid pistons in a very short time. Fluid pistons with damaged rubbers will allow mud to leak by and wash out the liners. New piston rubbers should be used with new liners; the old rubbers may damage the liner prematurely. Liners must have a generous chamfer at the head end to facilitate installing the fluid pistons without damaging the lips of the rubbers. Liners which are undersize on the outside diameter will be too loose in the fluid end, and the excessive clearance will allow the liner packing to extrude and fail. Many liner packing difficulties can be traced to too much clearance between the liner and fluid end adjacent to the liner packing space.

Liner packing usually fails because of extrusion of the bottom or inner ring into the clearance space between the liner and the fluid end. In addition to keeping the clearance space at a minimum, the bottom ring should be examined every time a liner is changed, and replaced as often as needed. The outer packing ring probably will not need replacing as often as the inner one.

Keep the liner spacer set up tightly at all times. Loose liner spacers allow the liner to work and wallow out the fluid end. Working or end movement of the liner accelerates the extrusion of the liner packing.

Valves and seats will take considerable wear before being replaced, provided the rubbers are kept in good condition to seal against leakage. The metal part of the valve forms the support for the rubber seal. Wear or small washes in the area where the metal part contacts the seat usually cause no harm until they reach the point where the effectiveness of the rubber seal is endangered. Worn or damaged rubbers should be replaced as soon as discovered. Valve seats which are washed or damaged in the rubber sealing area should be replaced immediately. Failure to make these replacements may result in a washed-out valve deck. When replacing valves, make sure that the tapered surfaces of the bore in the pump chamber and the outside of the seat are clean and dry. Rust or sand particles will hold the seat away from the bore and allow the mud to wash out the valve deck. Valve seats depend on the taper and friction between mating parts to hold them in place. Oil or grease on the surfaces reduces the friction and allows them to slide when subject to the heavy loads encountered.

This same rule of clean dry surfaces applies also when a piston is

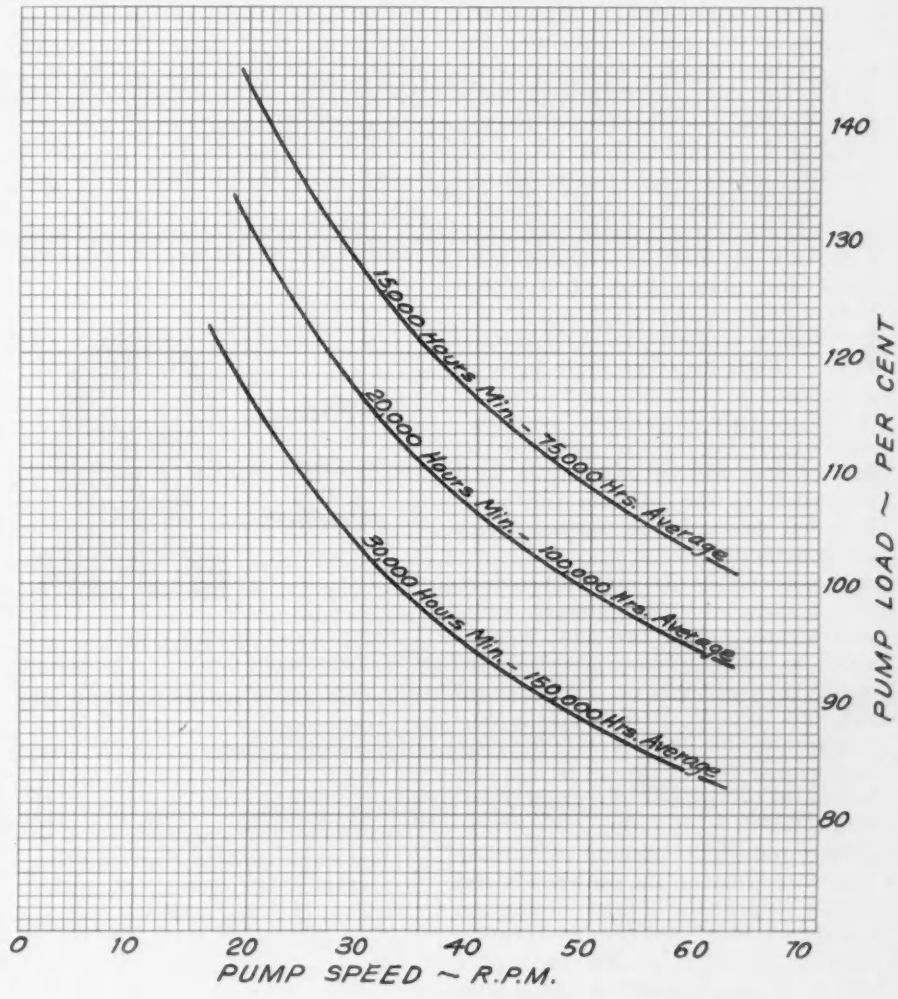


FIGURE 1. Bearing life as related to pump load and pump speed.

installed on a piston rod. Many cases of loose fluid pistons have been caused by oily or greasy surfaces on the taper.

Worn, scored, or pitted piston rods should be removed from the pump. It is impossible to pack off a scored or pitted rod, since the rod will tear up the packing with only a few strokes of the pump. Packing cannot be expected to do a really satisfactory job if the rod is worn undersize in diameter more than about 1/32 inch. Much packing trouble is traceable to too much gland pressure on the packing, which then binds and scores the rod. If the rod surface is smooth and polished moderate gland pressure should be sufficient to keep the packing from leaking. Flushing the rod with oil instead of water seems to preserve the polished surface and reduce the rate of wear. It is generally conceded that some form of self-sealing or V-type packing is best, but more information is needed as to how to use this packing most effectively.

Excessive fluid rod and diaphragm packing wear and rod fatigue can be caused by not keeping the rods centered in the stuffing boxes. Power end crossheads should be adjusted and fluid piston bodies replaced as needed to keep the rods centered. When a rod is off-center, it bears against the packing at one point, deforming the packing and causing excessive wear. At the opposite side of the rod, there will be a clearance between the packing and the rod, which allows air to enter the pump on the suction stroke and mud leakage to destroy the packing on the discharge stroke. Misalignment of rods, due to worn crosshead shoes and guides and worn piston bodies, imposes an extra strain at critical points, resulting in early fatigue failure. Rods must be kept tight in crossheads or extensions and lock nuts pulled up tight to prevent "working" and fatigue failures. Do not mar the surface of a rod by gripping it with a wrench in the packing rub area. Knurled or undercut wrench grips are provided.

When crossheads are adjusted to center rods in stuffing boxes, sufficient running clearance must be provided to avoid binding. A clearance of about .010 inch on large pumps and .006 inch on small pumps is usually permissible for normal direction of rotation. Practically all pumps can be run in the reverse direction of rotation with no alteration except possibly to reduce the amount of running clearance between the crossheads and guides. Since the forces acting on crossheads during reverse rotation tend to lift them against the upper guides for most of the stroke length, excessive clearance will cause a knock at each end of the stroke when they drop back onto the lower guides. The suction and discharge piping of a circulating oil pump, either for power end lubrication or for fluid rod lubrication, will have to be reversed when a slush pump is run in reverse rotation.

The mud baffle and diaphragm packing are designed to keep mud out of the power end and should be kept in good condition. The mud baffle deflects fluid rod stuffing box leakage and prevents it from reaching the diaphragm packing, but if the leak is really bad, the mud spray will fill the cradle section, find its way past the baffle, destroy the diaphragm packing, and enter the power end to contaminate the oil.

Dirty, contaminated lubricating oil is probably the cause of a major part of power end troubles. The mixture of oil and mud is a good lapping compound and quickly wears the working surface of bearings, gear teeth, and crosshead slides, causing them to be loose. Water in the oil will etch bearing surfaces and gear tooth faces, reducing their usefulness. The cheapest and best insurance against excessive power end trouble is the use of good, clean oil of the proper type. The pump manufacturer recommends lubricants, and these recommendations should be followed. There are, however, only three main requirements the oil has to meet: first, it must be clean; second, it must be non-corrosive; and third, it must have sufficient film strength to carry the gear tooth load.

The effectiveness of lubricating oil varies with the changes in the surrounding temperature. It gets less viscous, or thin, when heated and more viscous, or heavy and sluggish, when cold. Use a relatively heavy viscous oil during the hot summer months and a lighter, less viscous oil during the colder season. For subzero temperatures, consult the pump manufacturer.

The importance of clean lubrication cannot be over-emphasized. Analyses of samples of oil taken from many pumps now in operation will show surprising results as to the amount of water and grit they contain. Contamination can be kept at a minimum by seeing to it that the fluid rod packing and diaphragm packing are kept in good condition and by changing oil in the power end at three or four month intervals or oftener as needed. If a large amount of mud does not enter the power end, drain the oil as quickly as possible, flush out the power end and parts thoroughly, wipe inner surfaces with rags where indicated, and fill with clean oil. Find the cause for the mud getting into the power end and remedy it before starting the pump.

The bearings of the power end should be kept adjusted as recommended by the pump manufacturer. In the presence of good clean oil, bearings will run for long periods before adjustment is needed. Bearings quickly develop looseness and require frequent adjustment when subject to the lapping action of an oil and mud mixture. It is an established fact that bearings cannot be expected to perform satisfactorily if they run in dirty oil. Where bearings are worn and cannot be adjusted, it is necessary to replace the worn bearing with a new one. When replacements are necessary, replace the entire bearing and not just part of it, as for example, a cone or cup. It is impossible to obtain good performance and life from a bearing if a new part is used with old parts. Replacements can be much more expensive than changing the oil to keep it clean.

There should be no looseness in the crank pin bearings or the main bearings. The load on these bearings changes direction with each reversal of stroke, and any looseness will result in a severe shock when the clearance is taken up. The stresses due to impact or shock loading are incalculable, but it is a matter of record that many broken shafts, cranks, connecting rods and bolts can be traced to loose bearings. Under impact loading, the stress at some point in a shaft or crank may

About the Author

WILLIAM J. REDMAN attended the University of Pittsburgh and Carnegie Institute of Technology. He joined Oil Well Supply Company at the Wilson-Snyder plant in 1923 as a draftsman, and in 1942 was appointed assistant chief engineer. In 1948 he became division chief engineer of the Wilson-Snyder Manufacturing Division of the company, a position he now holds. Redman is a member of ASME.

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be above the endurance limit of the material, and a crack will develop which, in all probability, will cause the part to fail. Though the peak stress may be in only a very small region of the part, the crack may form and, once formed, will spread under the influence of only moderate loads and ultimately lead to failure of the part. This accounts for the fact that many failures seem to occur under normal loads, whereas the truth is that the crack formed at some remote previous time under a severe overload and has taken all of the intervening time to spread and cause failure. Periodical inspection can detect the presence of fatigue cracks before final rupture occurs.

All bolting throughout the pump should be kept tight. Here again, looseness will cause impact loading. Bolting should be checked for tightness after the first two or four weeks of operation, and thereafter at regular inspection periods. Bolting for valve covers and fluid cylinder heads, which have gaskets, should not be tightened in sequence around the circle but should be drawn up evenly by tightening a bolt on one side, then one on the diametrally opposite side until all bolts are tightened. This procedure distributes the load uniformly around the gasket to provide a more effective seal. Gaskets should be handled carefully to avoid damage when installing and removing covers. A damaged gasket wil not seal properly and should be replaced immediately.

The pump should be set on level, solid ground. Uneven ground under the skids will warp the pump and cause serious strains. Pump skids should be adequate in size for the weight of the pump and long enough to prevent damage to the pump while loading onto and unloading from trucks when moving the rig.

The suction line should be short and direct and not smaller than the size of the pump suction connection. Long radius bends should be used in order to obtain best flow characteristics. Suction lift should be kept as low as possible. Where long suction lines and/or high suction lift is unavoidable, the use of a suction air chamber usually prevents fluid end knocks due to water hammer. Air pockets and air leaks must be kept out of the suction line. Where air pockets are present, air may be drawn from them in sufficient volume to break the column of fluid in the suction line and cause the pump to lose its prime. Air leaks in the suction line can also cause the pump to lose suction, and in any event, they will lower the efficiency of the pump by reducing the amount of mud that is drawn in and discharged during each stroke.

A suction strainer will keep debris out of the pump. Large objects, entering the pump, can lodge under the valves and may cause a washout. A strainer will not function properly unless cleaned frequently to remove the trash which may obstruct the flow. Sand which settles out of the mud can also block the suction passages. Most fluid knocks are caused by the pump not filling completely during the suction stroke. Examine suction line and strainer for leaks or obstructions. Also check the valve cover and fluid cylinder head gaskets for air leaks. A strainer in the discharge line is a good safety precaution since it will catch any small pieces of ruber from valve discs or other small trash which may get into the pump. This is particularly important for jet bit drilling where such objects may clog the small water courses.

Idle Pumps

When a pump is idle, especially in a humid atmosphere, rust and corrosion will attack exposed finished surfaces. Idle pumps, espeecially standby pumps, should be protected by coating exposed rods and other surfaces with a light grease. Wipe the rods clean to remove any windblown grit before starting up. When a rig is stacked, the pumps should be protected by weather-proofing all exposed finished surfaces, including rods, shaft extensions, and the grooves of the V-belt sheaves. Oil should be drained from the power end so as to remove along with it any grit or water which may have accumulated. Fill the pump with the required amount of fresh, clean oil when it is put in service again. Drain the fluid end at all times when the pump is likely to be standing idle in freezing weather. It is easier to prime a pump than to repair broken castings.

Spare parts are kept on hand so as to be able to make replacements quickly when necessary and so avoid keeping the pump shut down until a part can be obtained from the supply store. However, they are of little use and a waste of money if they are allowed to get damaged through careless handling and storage. A protected place should be provided in the tool shed where they can be stored so that heavy tools and other parts cannot be dropped on them.

All of this sounds like an ambitious program and a lot of work. However, all of it is being done now as a matter of necessity to repair failures as they occur. It is better to institute a program of periodical inspection and preventive maintenance to detect weaknesses before failure occurs. Such a program could easily cover:

Liner sizes to keep within the manufacturer's rating for the pump.

Suitable relief valve, set to suit the liner size used.

Liners and pistons in good condition. Full size outside diameter of liners to suit the fluid chamber.

Liner packing in good condition and liner spacer set screws kept tight.

Valves and seats properly installed and flexible sealing discs in good condition.

Piston rods smooth, not worn excessively, and centered in the stuffing boxes.

Piston rod packing properly installed and adjusted.

Diaphragm packing in good condition and extension rods centered in the packing space.

Power end crossheads properly adjusted and fluid piston bodies in good condition to keep the rods centered in the stuffing boxes.

Good, clean oil in the power end. Change oil frequently to remove contamination.

Bearings adjusted as recommended by the pump manufacturer. Replace worn bearings which cannot be adjusted. Replace the complete bearing and not just part of it.

Check all bolting for tightness at regular intervals and in any event after the first two to four weeks of operation.

Keep suction line short and direct with long radius bends. Keep suction lift as low as possible. Avoid air leaks and air pockets in suction line.

Use a suction strainer and clean it frequently. Do not let sand accumulate in the suction line or passages of the pump.

Use a strainer in the discharge line to catch small objects which get past the suction strainer or break off from the valve discs or piston rubbers.

Use a full size discharge line from the pump to the standpipe.

Protect idle pumps from damage by coating exposed finished surfaces with light grease. Wipe off before starting up.

Protect stacked pumps by weather-proofing exposed parts.

Drain fluid ends when pumps are to stand idle in freezing weather.

Protect spare parts by providing safe storage space.

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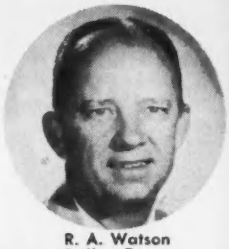

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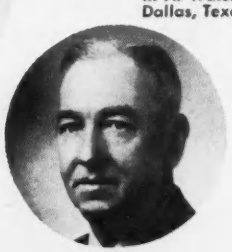

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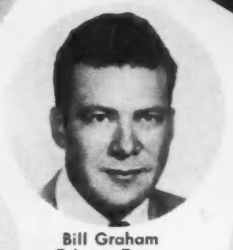

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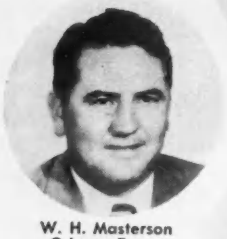

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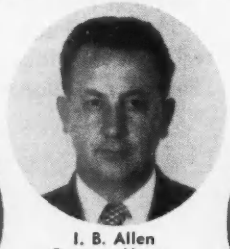

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A Contractor Figures *His Costs*

By JACK H. ABERNATHY
Big Chief Drilling Company, Oklahoma City

SUMMARIZING COST factors which must be weighed before a sound bid can be offered for drilling a given well, the author outlines a procedure which enables all available information to be evaluated and a basis developed on which the rate per foot can be set. This paper, originally presented before a local meeting of the AAODC in Tulsa, was also read before the annual meeting of the association in Dallas.

THE things a drilling contractor always wants to know are:

1. Where is there a potential job—a drill site—for one or more rigs in his operating territory?
2. How can he get to bid for the drilling of that test or tests?
3. What will it cost him to drill the well?
4. What margin over estimated cost will yield a reasonable profit and still be the low bid?

Items 1 and 2 are involved in the sales aspect of the well-digging business and are intimately associated with the contractor's past record and experience, including his success, or lack of it, on jobs for the well owner at earlier dates. In general, the contractor keeps close watch on the various reporting services which often give clues to new wells; he tries to visit the responsible operating personnel of active oil companies often enough to keep his name before them, but not often enough to invite criticism. In short, he uses recognized sales techniques and procedures in locating a job and in getting on the bid list for that job. Items 3 and 4, however, are those with which this paper deals.

Assuming that the contractor has been given the opportunity to bid for a job and that he has a rig available which will meet the customer's specifications, he starts gathering cost data by proceeding much as follows:

FIRST: His own records are checked to determine if he has drilled a test near the proposed location. If so, his own files may give good data as to drilling conditions. However, if the reference well was drilled four or more years ago, it is not easy to judge present day costs and present day drilling rates therefrom.

SECOND: The contractor sends a drilling superintendent, toolpusher, engineer or truck pusher to the location. As a result of this first inspection, the contractor expects a report covering all of the following important points:

A. Condition of roads and location with an estimate of bulldozer time to get both in shape to move the rig onto the drill site. Can pits and cellar be dug readily, or are special arrangements necessary? How much will these items of dirt work cost?

B. Availability of fuel: Are there gas lines, gasoline plants or producing oil or gas wells in the vicinity? If so, what are line pressures, separator pressures, volumes? Will fuel be available continuously, or do plant or well operating schedules vary with the possibility that fuel supply may go off without warning? If necessary to use butane or diesel fuel, are the roads such that trucks can get to the job in any weather, or should excess storage be provided? How much will fuel, including lines and installations, cost?

C. Water supply: Are running streams or large stock ponds near the location; will it be necessary to build dams or dig a water well; if in cold weather can the necessary lines be buried or arranged for rapid complete drainage? How much will water cost?

D. Owner or tenant: Can the move into the location be made speedily and efficiently with the occupant's cooperation? More than one contractor has had a fleet of trucks shut down by a strand of wire and a shotgun at a cost of $50 per hour or more for trucks alone, without considering crew or rig time. How much will it cost?

E. Other information of value: Is the location or road likely to be flooded in times of high water; where can the crewmen live? Are field welding and emergency repair facilities available? These things all affect costs.

THIRD: The contractor's geologist is called in to advise if the test well may anticipate normal drilling, or if unusual conditions may be found. These may include steep-dipping formations, zones of lost circulation or unusually high pressure; granites, cherts or other very hard substances, or perhaps faults, over-thrust folds or other complex structural features. Competent geological data are an essential, for in many areas geological conditions and therefore drilling costs can differ considerably by offsetting locations. One of the great hazards of the drilling business lies in the fact that even with the best of ge-

ological talent it is often impossible to determine accurately the sub-surface conditions which must be dealt with. The well-owner usually has much more data concerning these things than does the contractor, who must do a good deal of shrewd guessing. Only rarely is the well-owners geological data made available to the contractor for use in anticipating drilling problems.

FOURTH: Bit manufacturers, mud sales organizations, oil producing companies and other contractors are checked as information sources, and in recent years the trade journals have given the contractor real help by publishing feature articles dealing with drilling problems in many fields. The contractor finds frequent need to refer to his file of these articles.

FIFTH: The contractor's accounting department furnishes data as to the operating cost history of the rig in question, and transforms the Superintendent's or Engineer's service data on the rig and drill pipe into per day or per foot costs for these very real, but hard-to-evaluate cost items.

SIXTH: With all basic data for the job assembled, the contractor proceeds to prepare his cost estimate. For this discussion, it is assumed that the location is a wildcat not far from the Lindsay, Okla., area, and that the contract will provide for drilling on a footage basis to the top of the Bromide (Simpson) formation at 10,000 feet. In the Lindsay area the data developed by the preliminary investigation will be about as follows:

Estimated operating days	95
Estimated number of bits (9″)	105
Type rig—internal combustion, approx. 1000 to 1200 h.p. in engines	
Type derrick—30′ x 136′ conventional with 8′ or 10′ substructure	
Estimated rig up time	15 tours
Estimated tear down time	6 tours
Fuel	Butane
Length of move	107 miles
Trucking rate for move	51c per 100 pounds
Weight of rig and drill pipe	650,000 pounds

and, using the above data, the COST ESTIMATE is calculated.

1. Rig up and tear down—direct labor plus toolpusher amounts to about $100 per tour for 21 tours.....	$ 2,100.00
2. Rig operating costs—all labor directly chargeable to rig, including pusher (not his expenses); insurance of all kinds; ad valorem, social security, and all other taxes except income; materials and supplies, including hand tools, light bulbs, wiping rags, paint and kerosene; engine and rig repairs; tool joint dope and oils and greases (these items alone total $31.50 per day for a heavy rig). Repairs especially vary considerably from well to well, thus a history of rig operating costs for the specific rig on a succession of jobs must be averaged for the estimate. If the rig is relatively new, $475 per day is a good average for all these items, and in 95 days, the rig operating cost will be.....	45,125.00
3. Bits—105 at $150.00 each.	15,750.00
4. Trucking and transportation: 650,000# at 51c per 100 lbs. .....$3,300.00 Rig up trucking and winching .. 300.00 Trucking during operations, 95 days at $20 per day 1,900.00	5,500.00
5. Pits, cellar and dirt work (steel circulating pits on deep wells)	750.00
6. Derrick costs	4,000.00
7. Fuel and water (1400 gallons of butane daily at 6c per gallon is $84 daily and water cost at $10 daily), both for 95 days total....	8,900.00
8. Rentals and miscellaneous (straight hole instrument).	750.00
9. Drill pipe repairs.....	1,000.00
10. Wire lines—1 line will drill two wells; cost $2600 per line	1,300.00
Total direct drilling cost..	$ 85,175.00

About the Author

JACK H. ABERNATHY was born in Shawnee, Okla., and obtained his B.S. degree in petroleum engineering from the University of Oklahoma in 1932. He joined Sunray Oil Corporation, Tulsa, as engineer, and later became chief engineer. Thereafter he went to The Superior Oil Company, Tulsa, as chief engineer. In August, 1942, he became chairman of the Engineering Committee of the Oklahoma City Wilcox Pool Engineering Association, and then returned to Sunray as assistant general production superintendent. In November, 1945, he became associated with Big Chief Drilling Company.

1. Rig depreciation—$300,000 replacement cost will have about 25%, or $75,000 salvage value. Depreciation sustained will be about $225,000. Efficient life of rig is about 1500 operating days. Per day cost is $150 and for 95-day job rig depreciation is .....$	14,250.00
2. Drill pipe and drill collar depreciation — 4½″ grade E drill pipe costs about $4.10 per foot with tool joints, or $41,000 for a 10,000′ string. Will drill about 60,000′ of hole, thus drill pipe depreciation will be about 1/6 of $41,000 or	7,000.00
20 drill collars cost about $20,000, $1,000 each and will drill about 70,000′ of hole. Depreciation is about 1/7 of $20,000, or.....	3,000.00
3. Field overhead—tool pusher expenses, his automobile and daily telephone calls—$25 per day for 95 days..	2,400.00
Total, intangible costs....$	26,650.00
GRAND TOTAL, COST FOR DRILLING WELL	$111,875.00

Cost per foot..$ 11.19
Cost per day..$1,177.00
(It must be borne in mind that depreciation figures vary markedly and service life of the drilling string under conditions other than those specified may be much shorter or longer than used above as examples.)

The contractor's cost, as calculated above, is a field cost only, and is roughly comparable to the "lifting cost" for producing a barrel of oil. Among the additional costs which must be included in the final figures are the following:

1. Accounting and materials department costs;
2. Safety, engineering and geological costs;
3. General and division drilling superintendent costs and expenses, including offices and camps;
4. An allocation to cover the all-too-frequent severe losses encountered in the drilling business;
5. Cost for financing;
6. Cost for pensions, bonuses, etc. The successful contractor must have well-trained, efficient personnel, and his employe benefits as well as wage rates must be high enough to attract and hold first-class men on a seven-day per week job;
7. General overhead, salaries, rents, phone calls, etc., including all the costs of locating jobs and soliciting business. (A bid submitted by the contractor, whether successful or not, can cost him several hundred dollars.)

The sum of all such costs, of which

• CONTINUED ON PAGE 130

Surface Casing *Failures*

By B. B. SMITH
Vice President and Manager of Operations, Loffland Brothers Company, Tulsa

IN the past few years the drilling contractor has encountered an increasing amount of trouble with the failure of surface casing during the drilling of a well. It may be that the increase in total number of rigs running has made this problem appear to be more frequent, although there may not be any increase percentagewise to the number of wells drilled. The increase, if any, is probably attributable to the fact that the shortage of casing has resulted in the use of a considerable amount of inferior surface pipe. This can be either second - hand pipe or pipe that is not the same weight, grade or type normally used. At the request of the AAODC Program Committee, I have reviewed this situation with a number of contractors and operators and have put down their ideas as to the handling of surface casing, together with my own, and I hope the following will be of benefit to the industry in helping to eliminate or reduce this kind of trouble, which can cost the industry many thousands of dollars a year.

IN RECOGNITION of the increasing amount of surface casing failures encountered by the drilling industry, the author analyzes possible causes of failure in surface strings and points to preventative measures. This paper is substantially as presented before the tenth Annual Meeting of the American Association of Oilwell Drilling Contractors in Tulsa, October, 1950.

It has always been recognized that any surface casing failure has been the responsibility of the operator, unless that failure is a result of negligence on the part of the drilling contractor. As a general rule, it is agreed that failures at the top of the string are more apt to be the responsibility of the contractor, while failures at the bottom of the surface casing are seldom affected by the contractor's method of operating. Most top failures are a result of not having the rotary table lined up, or failure to have a rubber protector on the kelly sub, or a crooked kelly joint. The result of such practice would be the top joints being worn thin, or a hole being worn through the pipe in the top 45 feet, or a loosening and resultant failure of the top joints.

A hole started straight and kept straight will reduce the possibility of surface casing failures; therefore, it is evident that the proper way to start a hole is to be sure that the rig is properly lined up and that all equipment is in its proper condition. In keeping the hole straight in some areas the proper procedure is to drill a small hole, taking surveys at intervals of from 100 feet to, but never exceeding, 250 feet. The small hole will then be reamed out to the proper size with a pilot bit. It is not good practice to use a flat bottom bit, due to the fact that this type has a tendency to sidetrack the hole if a bridge is encountered while reaming down. A check survey should always be run at the bottom of the reamed-out hole. Another practice is to drill a regular size hole. This is in areas where holes are easier to keep straight, or where smaller size surface casing is set. The rat hole and reaming practice is generally used where 10¾-inch or larger size pipe is set. It is good practice to measure the surface casing on the casing rack at the time the surface hole is being made, in order to know the exact amount of hole that is required. It is not good practice to make too much hole and swing the casing too far off bottom. In this connection a lot of attention should be paid to the formation that the casing will set in. In wildcat areas the surface casing should be bottomed in lime or shale. If it is discovered that the amount of casing on hand requires a hole that will set the casing in sand, the contractor and the operator should get together and agree to drill on down until a more solid formation is encountered.

In my opinion it should be regular practice for all operators to run centralizers on their surface casing to insure centering of the pipe in the hole in order that the cement can get all around the casing for at least 100 feet or more from bottom. Almost all operators are running centralizers on their long strings of casing but very few use them on their surface casing. To me, it is just as essential to run centralizers on surface casing as it is on the long string.

A combination float and guide shoe should be on the bottom of the casing, and an additional float valve should be used from 45 to 60 feet off bottom in order to keep all possible contaminated cement in the casing. Some trouble results when operators depend only on a combination float and guide shoe; then when the plug is pumped down, all the contaminated cement is left around the bottom joints of the casing instead of up inside the casing as would be the case when an additional float valve is used.

The welding of surface casing is a very important factor. The casing should be made up tight, then spot welded in about four places of about 1½ inches in length around the top and bottom of the collar and floats. It is bad practice to weld the pipe all the way around unless slip joint casing is being used; then, of course, it is essential to weld it all the way around, but only with the proper kind of rod and proper amount of heat as recommended by the manufacturer of the casing.

In many instances when threaded and coupled surface casing is welded in the field, the work is done by any oil field welder. He may never have had experience in welding casing and may not know any better than to weld the collars and floats all the way around. He may not know the proper size rod or the proper amount of heat to apply to the rod. Consequently, the steel structure of the casing is broken down at the bottom of the weld, to

the extent that it takes very little vibration to break the casing off. If for any reason the casing loosens up at the bottom of the string, the shoe or any one of the welded joints may break off, and trouble starts when the casing drops down.

Particular attention should be maintained as to the proper amount of cement used in cementing surface casing. Operators who have the least trouble use a sufficient amount of cement from bottom to the top of the string. The operator should figure the proper amount of cement it will take to fill the hole on the outside of the casing, and add a sufficient amount to take care of any possible cavities. Then after the plug is pumped down and allowed to set a few hours, additional cement should be put in around the top either by dumping in the proper amount or by running some small pipe down beside the casing, then pumping in enough to finish filling around the casing. In some cases cement returns are noticed long before the plug is down. When this happens it is generally because the plug is pumped too slowly and the cement has channeled. It is good practice to use as much volume as possible to pump the plug down in order to raise the full column of fluid around the outside of the casing in order to avoid this channeling. Another reason surface casing should be cemented to the top is that in all areas everyone is becoming more blowout-preventer conscious and demanding the heavier blowout preventers anchored properly. When casing is left loose at the top it is impossible to anchor the preventers to where they will not vibrate and shake loose.

The proper procedure in drilling the plug in surface casing is to use a rock bit. A blade bit or drag bit has a tendency to hang up and may loosen the casing, or could possibly back the casing off. Particular attention should be paid to the rubber protectors used on the drill pipe. The proper number of rubbers should be used, one every joint, and the rubbers should be kept larger than the tool joints. Any time a rubber is let run out of the bottom of the surface casing into the formation, it is worn out in one trip. In this case the rubber should be changed and at all times a rubber of the proper size should be kept on the kelly sub.

There should be a better understanding between the operator and the drilling contractor when trouble is encountered with surface casing. At the least provocation, an electric log should be run to determine if the casing is parted. Then the loose joint should be cemented. In some instances a joint of surface casing has been known to fall 1000 feet and the hole finally lost, when it could have been avoided if it had been taken care of when first noticed.

There is a lot of money spent due to the lack of understanding between the men in charge of the company operations and the tool pushers in charge of the drilling contractor's tools. Neither representative is sure of where responsibility for the trouble lies; therefore, no one is taking the direct responsibility immediately and valuable rig time and other expensive undertakings are going forward without planning.

When the drilling contractor makes the amount of hole specified by the operator, and runs the casing furnished by the operator in the manner specified by him, cements the casing according to the operator's specifications, anchors the blowout preventer sufficiently, drills the plug with a rock bit, runs the proper number of right size rubber protectors on his drill pipe and kelly sub, and has his rig lined up properly and in good condition, he will avoid much surface casing trouble, and certainly will reduce to the minimum any responsibility of his if a failure occurs. If a failure occurs for reasons other than the aforementioned, in all probability it is the responsibility of the operator, and his representative should immediately take charge and assume responsibility for cleaning up the hole.

About the Author

B. B. SMITH was born September 23, 1903, and has been active in the oil and gas industries for more than 30 years He was associated with Meade Brothers of Tulsa and also with J. E. Mabee and Arrow Drilling Company. He joined Loffland Brothers in 1933. In 1946 he became vice president and was transferred to Houston as manager of the Gulf Coast division. In 1949 he was transferred to Tulsa and made manager of operations.

A Contractor's Costs

■ CONTINUED FROM PAGE 126

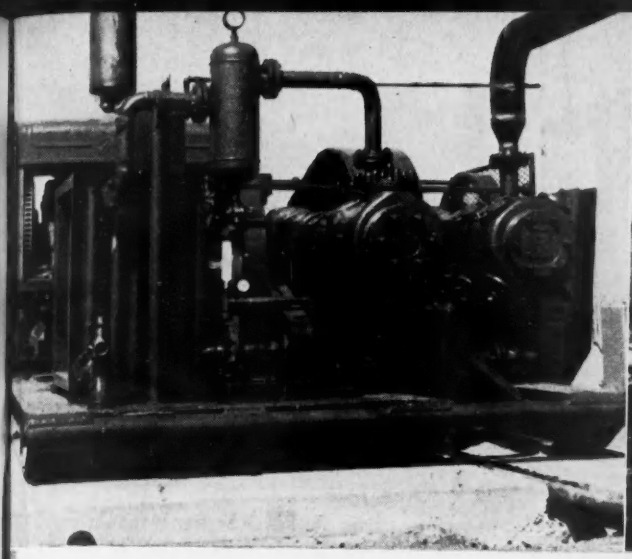
those listed are only a few, will vary considerably, depending on the contractor. It is safe to say, however, that a medium-sized firm with a fully-staffed organization will have to add 8 to 10 percent to its field costs to arrive at its actual cost for each job.

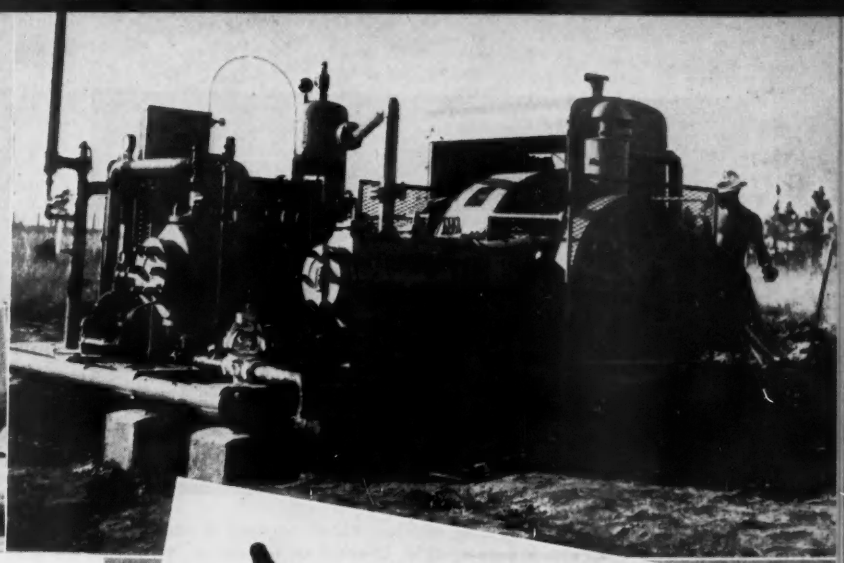
The contractor's markup for profit is influenced by many complex factors, among them being his own financial necessity to keep the rig working, the length of the job, the presence or lack of hazard, the investment in his rig, and the competitive nature of the market—that is, what he thinks his competitor will bid. On an annual basis, the contractor's customer may be sure that the contractor's profit, is quite modest.

It must be remembered that all the costs itemized above are based on about two-year averages. However, a number of expendable and capital investment items have increased sharply in price and wages are now rising. None of these higher costs is reflected in the data presented above, but when figuring on a long job, the thoughtful contractor must certainly take them into account.

Drilling contractors think they have done the oil producers a pretty good job on the whole. In the five years since the war, nearly all prewar rigs have been scrapped and obsolescent equipment has been replaced with new equipment. The resultant operating savings have been passed on to the oil producers, for drilling prices are now at an all-time low, which is truly a paradox in our inflating economy. This shows how a competitive industry that operates at a profit can reduce its costs to its customers. If there had been no profits, no modern rigs could have been purchased. If postwar rigs had not been bought, costs would have remained higher, and oil producers today would be paying more—considerably more—for their drilling.

We contractors say that this record shows that the drilling industry—led by the American Association of Oilwell Drilling Contractors, in attacking problems of efficiency and safety—has now matured; that it has discharged its obligation to its customers, and through its customers to the public; that it has, is, and will continue to provide the best of service at the lowest possible cost.





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4. 7" x 4⅛" x 9"—80 H.P., 40-Lb. Suction, 600-Lb. Discharge, 547,000 Cu. Ft. Per Day.
5. 9" x 4¼" x 9"—80 H.P., 10-Llb. Suction, 500-Lb. Discharge, 405,000 Cu. Ft. Per Day.
6. 4⅛" x 9"—45 H.P., 200-Lb. Suction, 600-Lb. Discharge, 630,000 Cu. Ft. Per Day.
7. 3½" x 11"—85 H.P., 800-Lb. Suction, 1750-Lb. Discharge, 1,792,000 Cu. Ft. Per Day.
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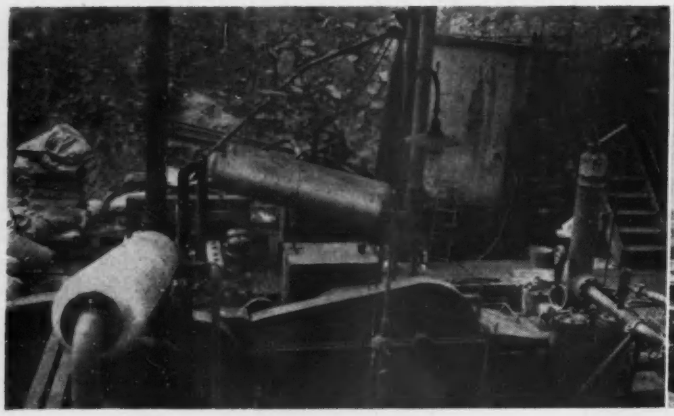

FIGURE 1. Method of mounting mufflers above engines to keep unit within limits of power and pump skid. Lowered outlet end of mufflers is to drain off condensation and quench water and protect engine from entrapped moisture.

FIGURE 2. Although apparently resting on the top header of the radiator, the muffler clears that unit, and is supported at the outer end by the extended drop leg of two-inch pipe which also serves as drain for excess quench water.

Muffler Mounting

To Check Back Drainage

PROTECTION of the valves, ports and upper cylinders of diesel or other internal-combustion engines against rust during down periods requires that adequate steps be taken to prevent the introduction of moisture either in the form of rain or in the form of flame-quenching liquid which may be drawn back into the engine at shutdown or subsequent cooling.

One company, recognizing the hazard to prime mover equipment during the down time, takes special precautions to insure engine protection through a unique method of setting the mufflers. Regardless of the type of fuel used or the make of the engine, exhaust fittings on the outside of the manifold are changed to the vertical position through the use of suitable fittings. Pipe of adequate size to carry the products of combustion without undue back-pressure losses is used as riser, being made long enough to place the adit end of the muffler at a height to clear any part of the engine and to allow sufficient working room for normal servicing operations.

The conventional factory-built mufflers delivered with the engines are used, as their design and construction are such as to eliminate back pressure and insure the desired degree of quiet in the exhaust. The mufflers have flanged ends to which are mated companion flanges on the ends of the risers, with the pipe flange set to allow the muffler to be set with a downslope of as much as 25 degrees below horizontal. Mufflers so mounted are set with their axis in the same vertical plane as that of the engine crank bearings, so as to occupy as little space as possible, and so they may be left intact with the engines when the equipment is lifted with a truck boom or motor crane. The mufflers are always installed at an incline to place the outlet end and tail pipe connections lower than the end flanged to the manifold fittings. The angle of inclination is approximately 20 degrees below the horizontal, which has been found adequate to prevent water or water vapor from traveling back to the inside of the engine valve chambers.

Tail Pipe Base

The stack, or muffler tail pipe base is of pipe considerably larger than the outlet fittings on the muffler itself. The design of this part may include a six-inch piece reduced at the tail pipe connection to four-inch. A stub nipple is welded at an angle to this part of the system to match the slope of the muffler, and it carries a companion flange to match the flange on the outlet of the muffler body. The weight of the muffler is supported by the pipe between the manifold and the muffler, and the radiator case, if the length matches these measurements. If not, a two-inch pipe standard is welded to the equipment substructure beneath the large part of the muffler tail pipe. This standard is used for two purposes—to support the muffler and to provide drainage for excess water introduced into the muffler to quench excess heat. A lip union is provided near the top of the standard so the unit as a whole can be removed from the engine without resorting to a cutting torch.

Flame-quenching water is injected at the outlet neck of the muffler by the use of standard copper tubing. Water is applied to the mufflers at the outlet and the lowered end for three reasons: (1) water introduced at this point comes in contact with the products of combustion after they have been expanded through the muffler and the temperature reduced so that a lesser amount of water is required to prevent flames from reaching the atmosphere; (2) introduction of water at the outlet neck prevents corrosion of the body of the unit due to rusting; and (3) when water is supplied at the tail pipe fitting, no moisture as liquid or vapor can backlash into the valve chamber through the manifold at the moment the engine is shut down. And by installing the muffler with the outlet 20 degrees lower than the inlet, rain water from storms cannot find its way into the engine through the exhaust system.

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(INCORPORATED)

Bethlehem, Pa.

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The many advantages of Form-Set preformed wire rope are now available at such slight extra cost that we can recommend it for practically all hoisting and operating duties. We say this with full confidence that extra value will be obtained by the purchase of this rope.

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The following well-known advantages of Form-Set preformed ropes over the non-preformed types have often resulted in economies that justified even the old higher extra cost:

* Because the rope is relaxed by preforming, single wires do not break as quickly from wear and bending fatigue. Being relaxed, they can wear thinner, hence longer, before breaking.

* Wickering of broken wires is much reduced. This makes the rope safer to handle; reduces the possibility of damage to neighboring wires.

* Form-Set rope is easier to install properly. Handles better ... seizing not needed. Has extra resistance to kinking, crushing, distortion. Spooling is tighter, more uniform.

At the risk of repeating, we'd like to close with this thought: Form-Set preformed rope is now within everybody's reach. It costs so little extra, you simply can't afford to pass it up.

Sincerely,

BETHLEHEM STEEL COMPANY

P. S. - On the Pacific Coast our wire rope is sold by Bethlehem Pacific Coast Steel Corporation; oil-country rope by Bethlehem Supply Company of California. Export Distributor: Bethlehem Steel Export Corporation.

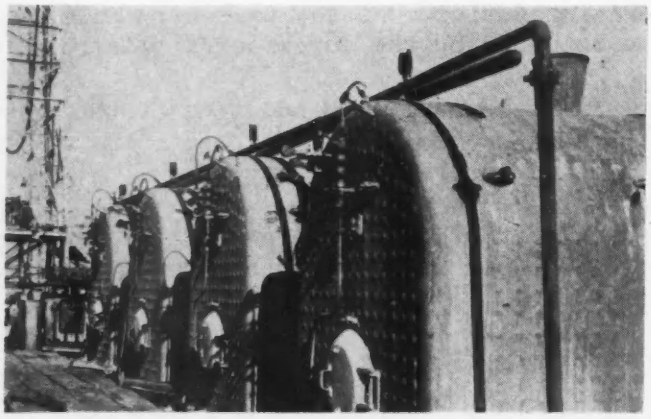
How to do it!

DRILLING HINTS

$10 is paid for each illustrated acceptable contribution. Mail to The Editor, WORLD OIL, P. O. Box 2608, Houston 1, Texas.

HOW TO—Remove Foam From Steam Boiler Battery

Foam generated inside a steam boiler is of considerable concern to the fireman. This foam is in a constant state of movement and serves as a blanket that covers the water surface and hinders efficient evaporation of water into steam. It also distorts the liquid level reading on the boiler water gauges.



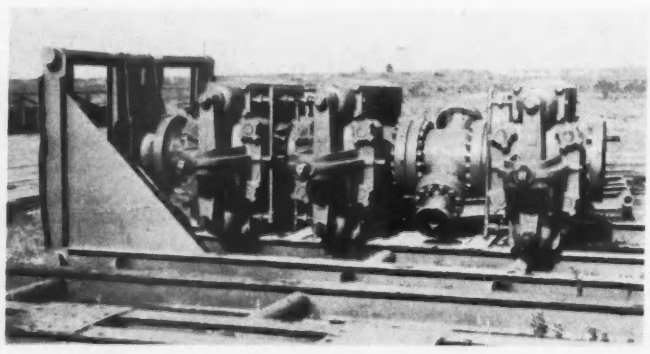
Blow cocks are provided on the boiler at three different levels to remove such foam that may form; however, blowing the foam from the boilers without any means of discharge results in a poor appearance around the fire box as well as on the boiler itself.

To circumvent such conditions, a foam discharge header is provided to carry the foam from all boilers to a pit or ditch. This header is made of two-inch pipe and rests on the outer skin of the boiler over the firebox end as shown. The second and parallel line to this header is the feed water supply line.

The upper hand cock is fitted with a tee so that a three-fourth-inch tube can be attached. A needle valve is placed in the line, and the tube then connected to the header by means of a pipe coupling welded to the larger pipe. In normal drilling operations, the valve is cracked slightly so that a small but constant flow of steam passes through the line. Should the water in the boiler foam without notice of the fireman, it will automatically blow itself out the foam discharge header and into a ditch. In case any one boiler begins to foam excessively, the fireman can open the valve on the foam line so that more steam and foam pass through the line.

HOW TO—Mount Preventers for Simple Installation

Connecting up blowout preventers and well head equipment involves making up dozens of flange bolts. The limited space below the derrick floor sometimes makes this work difficult. This is particularly true where three blowout preventers are used with a mud cross separating the top preventer as shown. It has become the practice of many operators and contractors to leave the preventers intact during rig moves, breaking the connection at the bottom flange only. When this is done, a bulky and heavy piece of equipment results. Blowout preventers cannot withstand heavy blows that other equipment can take, because they are fitted with hydraulic lines, and are precision made.



For protection of preventers left intact when removed from the location, many contractors and companies use a skid. This skid has special means of holding the units securely in place. Illustrated is a skid mounting three preventers and a mud cross. It is of special interest because it provides additional features not usually found on this type equipment.

To one end of the skid is added an extension of the framework at 90 degrees. This four-foot extension is adequately braced on both sides. A dome welded to the middle skid member serves to center the preventer and hold it in position prior to lowering the unit onto the well head. The extension makes it possible to elevate the preventer in a vertical position without strain on the flange bolts. It protects the preventers completely until they are ready to be lowered through the derrick floor into position. Once the skid is drawn upon the floor, it can be "up ended" on the extension skid with full protection. The only strain taken by the preventers is the vertical load when raised off the skid and lowered in place.

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OF A STANDARD DERRICK...

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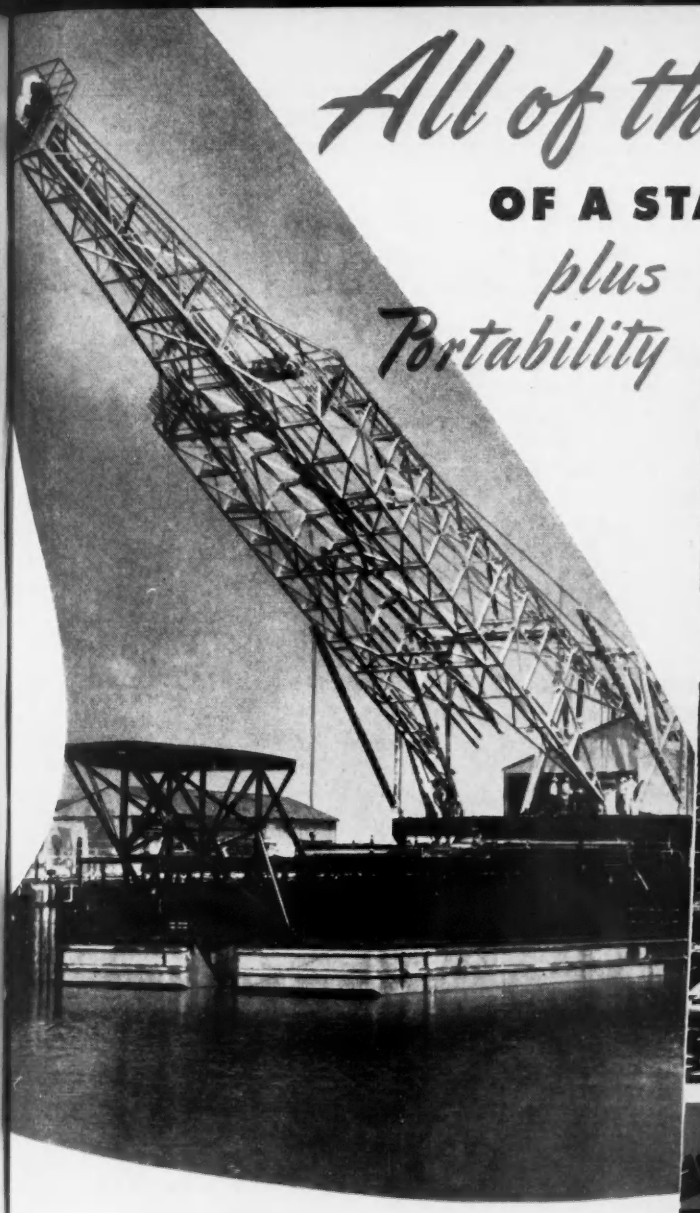

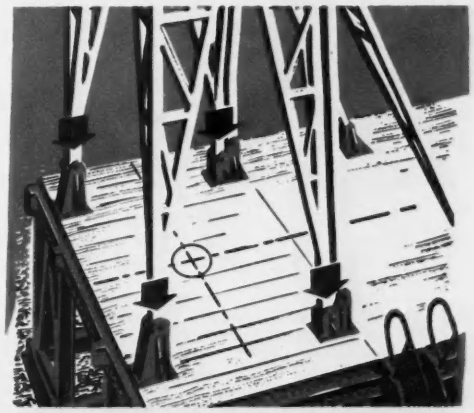

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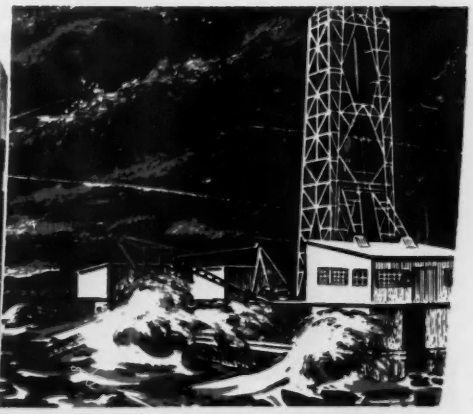
Emsco Portable Derricks are structurally sound. Pipe is racked inside derrick permitting *all four sides* to be laced. Standard derrick stability is achieved by equal loading of all four legs.



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Absence of internal bracing permits unobstructed view between driller and derrickman and insures free travel of all derrick equipment. Safe, efficient working platform is adjustable to meet all operating requirements.

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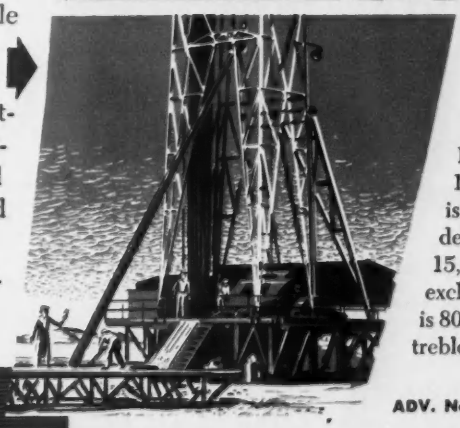
There's no drilling operation involving the use of a standard derrick where an Emsco Portable Derrick of comparable size can't be substituted. In addition to giving you the strength, structural stability and safety of a standard derrick, an Emsco Portable Derrick also gives you every operating advantage. For example, only Emsco manufactures a portable derrick in which casing can be run with a full setback of pipe standing. This is not possible with open face portable masts. ★ Nothing has been sacrificed to give you everything a standard derrick has to offer plus portability and quick, easy, safe field erection.

See our catalog in the composite catalog, pages 1437 to 1556.



STANDARD DERRICK CAPACITY IN ALL HEIGHTS

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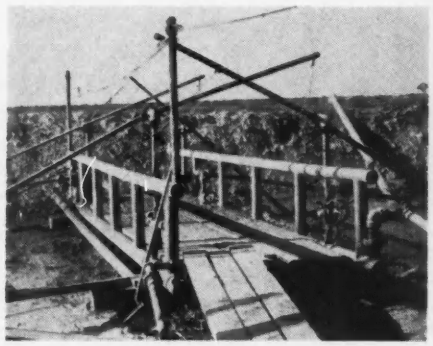
HOW TO—Use Skid as Mud Header

Long, rectangular pipe skids have proved practical in handling miscellaneous piping and equipment during rig moves. These skids normally remain at the rig as useless items during the drilling operation. Because skids represent an investment in steel, even though the pipe is salvaged, it is desirable that they be useful equipment during both drilling and moving operations.

The addition of a few extra fittings and valves will equip such a skid for use as a header to feed mud to the jet guns. The skid illustrated is not only equipped as a mud header for the mud guns, but is also connected to supply steam through the guns should it be desired.

The skid, made of conventional design with the exception that the skid runners and cross braces are interconnected, and sealed off at the ends, is equipped with four mud guns, two guns on each side of the skid. A coupling and hammer union are added to the near ends of each skid runner as shown so that supply lines can be easily connected. The line at left connected to the skid is for steam, and that



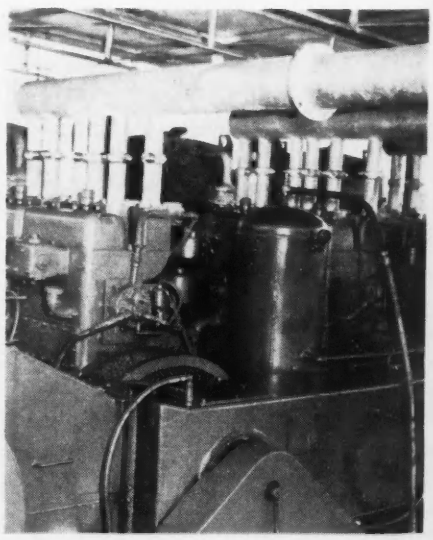
at right is for mud. Each gun, supported on a riser welded to the skid runner, is equipped with a mud valve.

The skid is placed between the settling pit and the sump pit. An overflow ditch at the far end of the skid connects the two pits. As long as mud is supplied to the skid, all four guns may be used to jet mud. When the mud supply line is shut off, the steam supply line can be used to jet the pit with steam if desired, or to clean mud from the skid prior to tearing down.

HOW TO—Connect Up Exhaust Lines

Exhaust lines are necessary on any rig employing internal combustion engines, not only to reduce rig noises but to convey the carbon dioxide away from the working area on the floor. Many of these lines are fabricated by the contractor or company and they are usually made of light-weight casing or line pipe. Because the lines are not factory standardized, means must also be provided to connect them to the engines.

Here is a neat way to make such a connection on multi-cylinder engines. Two possible means of disconnecting the exhaust line are incorporated in the design and construction of the assembly. Each exhaust cylinder is equipped with a riser of three-inch pipe that contains a two-bolt coupling. The riser is welded into the horizontal exhaust line made of 8 or 10-inch pipe. This pipe carries the exhaust gases beyond the edge of the derrick where they are blown into the air. In the horizontal run and just above the end of the skid on which the engine and accompanying power transmission are mounted is a flanged coupling containing three bolts. This is simply a flat faced flange and may



be disconnected by taking out the three bolts. If the head of the engine is to be removed, the individual cylinder exhaust risers are disconnected and the entire exhaust line removed. However, on rig moves, it is necessary only to break out the three bolts on the horizontal line and disconnect.

Have You Overlooked The Best Buy in Rotary Hose?

When you buy rotary hose today, you buy a piece of equipment that costs approximately $1500.00 . . . . not a $25.00 accessory.

Yet, one break or rupture puts your entire investment on the junk pile! Is this economy? However, here's what happens when you buy Goodall Long-Life Flexible Cord Rotary Hose: Goodall Rubber Company is the only manufacturer that can protect your rotary hose investment . . . because the Barney Coupling is the only rotary hose coupling that can be rebuilt back into the old hose. Thus, if a Goodall Rotary Hose is damaged, we simply reset the Barney Coupling for a nominal cost and your hose is then ready for additional service. This is economy!

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Can any other manfacturer match this Goodall economy and service? They cannot! So, in the light of these facts, why buy any other rotary hose? And never discard a Goodall Rotary Hose until you call us.

If you are not fully convinced of these facts, ask anybody who makes or sells rotary hose or write to me personally. We will contact you and fill in other details and answer your questions. Thanks.

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HOW TO—Make Boat Bumpers of Old Rubber Tires

Wherever there are marine operations, whether they are inshore or beyond the coast, there is a big demand for bumpers or guards for boats, tugs and barges. These so-called bumpers absorb the shock when a moving vessel comes in contact with an anchored barge or structure or a dock. The greatest source of raw materials for bumpers has been worn out heavy-duty truck tires, of which oil companies usually have a good supply.

When heavy tires are hung from the side of a floating vessel, they must be securely attached to a cable or rope. It is a difficult job to punch a hole in a tire to accommodate a cable, because the hole quickly closes when a punch is removed from the rubber surface. Here is an effective way to pierce old tires so that the hole remains open when the mandrel is removed.

A three-foot piece of 1⅛-inch diameter steel rod is passed through holes in two iron distance brackets welded to a vertical I-beam support in the machine shop area. The holes were large enough so that the bar can easily slide up and down parallel to the I-beam. The brackets are 18 inches apart and serve as a frame for the punch or rod. A half-inch iron bar is bent and welded to the middle of the punch rod in such a manner as to form a slot through which a lever is passed. This lever can be made of discarded angle iron bolted to the beam with a single bolt and extending through the slot on the bar, forming a handle which makes it possible for a man to exert a penetrating force on the rubber tire.

The device is mounted at a convenient height so that when a tire is held upright beneath it, there is sufficient clearance for the punch rod to make contact with the tire. A welding torch is used to heat the lower end of the punch to a cherry red, at which heat it is forced into the tire and burns a permanent hole in the rubber, making it easy to pass a cable or rope through the tire.

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Newly designed trip latch works on specially formed spiral thread; allows spear to be set for any weight casing within its range. Easily set with bolt or rod to insert in holes to screw collar down on spiral thread on mandrill, with latch held in until slips open to correct size to engage casing. When released spring raises slips to closed position for easy withdrawal from hole.

When ordering, give size and weight of casing to be retrieved.

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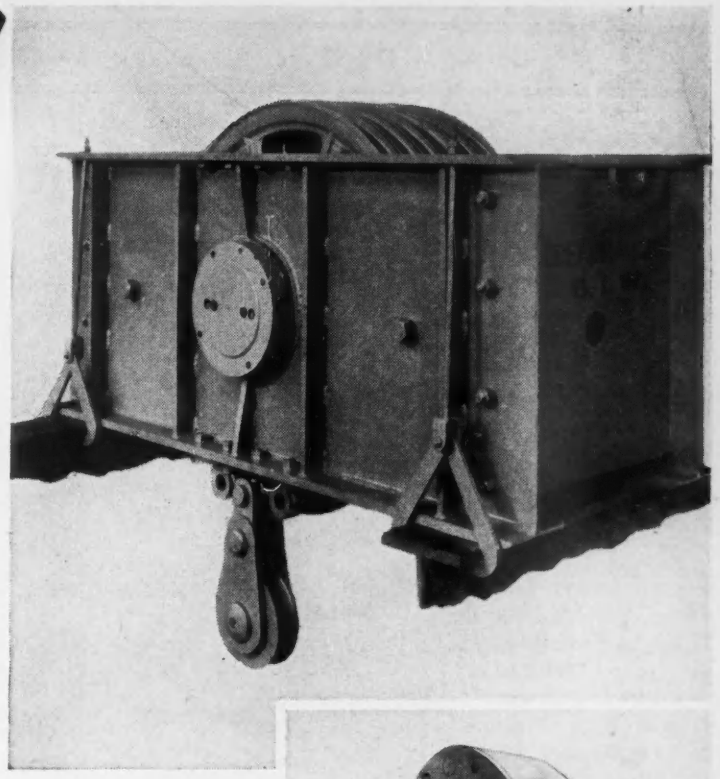

A little over a year ago, Beaumont Iron Works introduced its new Dreadnaught Type KN Crown Block with its companion Dreadnaught Type PN Traveling Block. The completely new ideas embodied in the design of this block combination made such excellent common sense that the Dreadnaught pair was an immediate success. Repeat orders coming in from major customers are the best endorsement of this new design.

NO OTHER CROWN BLOCK HAS ALL THESE FEATURES...

Space Saver—Centerline and narrow centers between sheaves permit block to be hoisted through water table in one piece.

Beam Support—Large diameter center pin mounted in box built into beam *on its center line.* New design provides extremely sturdy and rigid support and reduces over-all height of block.

Two Mountings—As center pin is on center line of beam, *either flange* of beam can be set on water table beams.

Four Positions—By turning block around, deadline sheave can be set in any of *four different positions* to minimize Brinelling effect on races, increasing life of bearings in end sheaves.

Bearing Life—A new idea in bearing design. Row of ball bearings in bronze retainers placed between each sheave. Acts as thrust bearings, resisting both end-wise movement and twisting effect caused by line passing between crown and traveling block.

All-around Protection—Labyrinth type seals between each sheave serve as grease seals and dust guards.

Rated Capacity—360 tons at 100 rpm—600 tons at 10 rpm.

STREAMLINED SPACE-SAVER TRAVELING BLOCK

Extreme Narrow-Width—Streamlined design did the "impossible." Although sheaves and bearings are of larger diameter, and maximum load capacity is built into design, the PN Traveling Block is so narrow and compact it does not restrict pipe racking space on deepest holes.

New Thrust Design—Each sheave mounted on radial roller bearing, separated by row of spherical ball bearings. Adds to bearing life and prevents radial rollers from skewing as *they carry no thrust load on the ends.*

New Strength—Load carried through rolled steel side plates. No spacer plates employed. The becket, capable of carrying load of one line, is buried within block.

Rated Capacity—300 tons at 100 rpm—500 tons at 10 rpm.

EXPECT the Best from BIW—Builders of Proved Drilling and Production Equipment for 40 Years.

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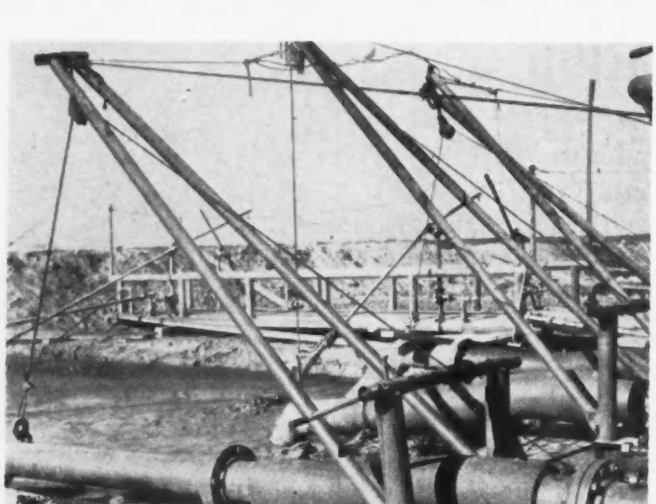
HOW TO—Construct Mud Pump Suction Mast Support

It is important that the suction line on the mud pumps be kept off the bottom of the pit, and that the intake be set a few feet below the mud sump surface. There are many designs and ideas incorporated in mud pump suction supports, but the one illustrated demonstrates a simplified, yet flexible A-frame mast that makes it easy to adjust the mud pump suction as the height of the mud changes in the pit.



A suction supporting frame is added to the fluid end of the steam mud pump skid. The A-frame mast is made of three-inch pipe, welded at the apex to a short header, and each end of the legs is flattened so it can be hinged to the skid. Two vertical supports of 5½-inch casing, about 28 inches long, are welded to the ends of the skid runners as shown. The tops of these vertical members are capped with a short three-inch nipple welded at 90 degrees to the larger pipe. These nipples form a hold-down bearing for the 2½-inch axle which serves as the winch in raising or lowering the suction line.

Matching holes drilled completely through the nipple bearing and the 2½-inch axle permit a bolt to be inserted through them to lock the axle in position. A crank for the winch is made of one-inch pipe inserted into matching holes cut in the near end of the 2½-inch axle. The supporting cable for the suction is attached to an eye welded to the suction intake nipple, then threaded through a pulley supported at the apex of the A-frame and wrapped around the axle of the shop-made winch. The A-frame is supported at the angle shown by a wire line anchored at the base of the surge chamber on the pump discharge. This light-weight unit can easily be dismantled for rig moves.

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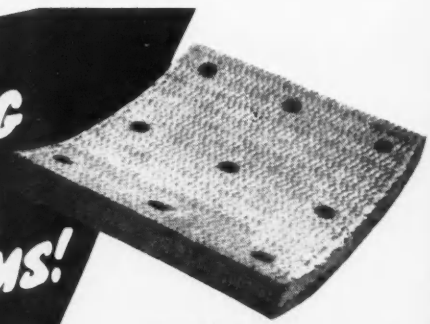

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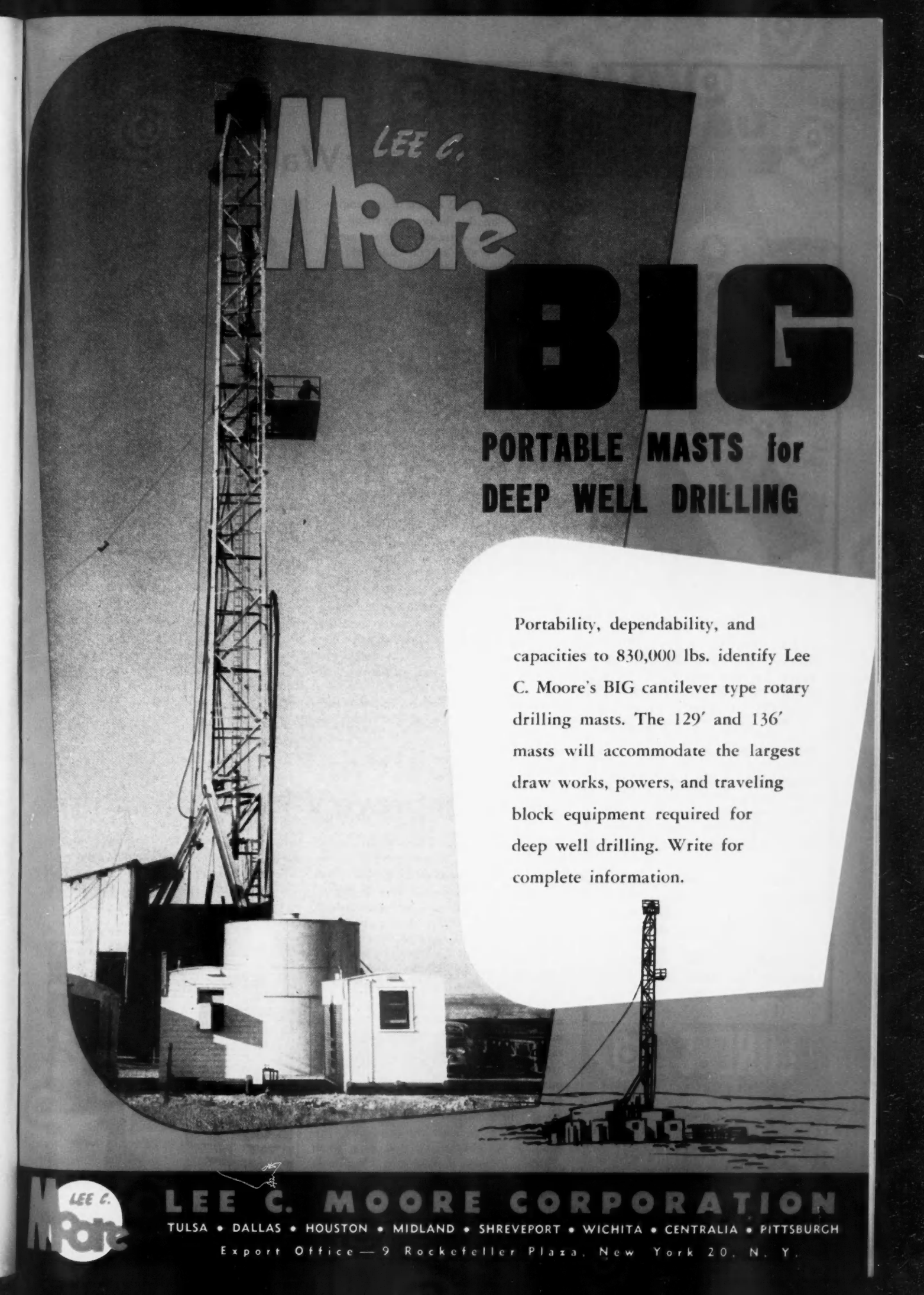
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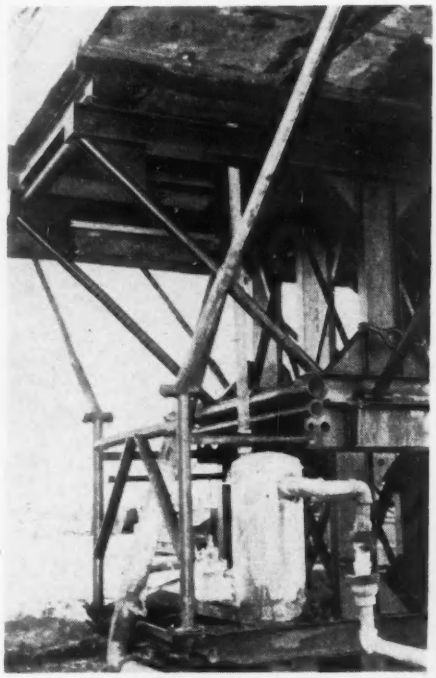
WICHITA FALLS, TEXAS

HOW TO—Support Walkaround Floor

The rather unusual design of the engine substructure on this heavy-duty steam rig has provided an extra-sturdy floor walkaround behind and on the sides of the drilling engine. Top runners on the upper substructure extend backward beyond the corner vertical I-beam members. The bottom skid beam also extends about three feet beyond the corner posts. These extensions add rigidity to the walkaround by simplifying the bracing problem.

The engine walkaround is made up in sections measuring about 4 feet wide by 10 feet long. Steel floor plate welded to an angle iron framework forms these sections. Each section is braced with 2½-inch tubing that rests against the I-beam runners on the upper skid. Because this skid runner does not extend far enough to the rear of the substructure, a removable pipe supporting member is welded as shown. It is made of three-inch pipe and equipped with square flanges at the bottom of each short vertical leg. These flanges can be bolted to the upper flange of the lower skid beam to provide a sturdy support. The floor braces telescope into three-inch angle members welded to the movable pipe support. The steam trap for the drilling engine is mounted inside this pipe framework and thereby made readily accessible.

The top beams on the upper substructure that extend to the rear of the engine are braced by welding three-inch pipe from their outer end to the base of the skid. This brace remains in place during rig moves. This design represents a departure from conventional bracing, because it provides more strength than normally incorporated in the engine walkaround.



HOW TO—Improve V-Ramp Structure

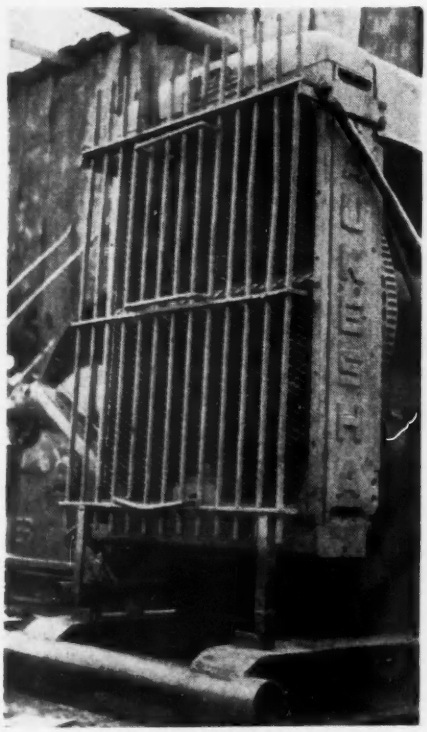
On derricks with 17-foot substructures, it is necessary to add side members to the steeply-inclined V-ramp to prevent drill pipe and other equipment from sliding off the ramp edges. On the reinforced steel plate ramp illustrated, centering guides allow tubular equipment to be drawn up onto the rig floor or lowered to the catwalk down the middle portion of the steel ramp.

These guides which also prevent equipment from sliding off the ramp edges, are made of two-inch pipe welded to the steel ramp plates. As shown, the guiding edges are welded to converge inward from the outer edges. The angle on the lower members is much greater than that of the upper ones. This is particularly helpful in laying down drill pipe. Since the ramp took considerable weight of the drill pipe when skidding it down the ramp, a sharp angle near the upper end might cause the pipe to jump the guides. However, by making a long neck on the guides, the pipe is brought toward the center of the ramp making it easier for those on the catwalk to rack the pipe.

HOW TO—

Make Sturdy Guard For Radiator Grille

A radiator grille guard which reduces the possibility of damaging the radiator core when the rig is moved between locations, can be made by the company welder using, for the greater part, salvaged materials. Lengths of ¾-inch sucker rod material, cut sufficiently long that they will extend above and below the radiator several inches, are run through holes drilled through three lengths of ½ x 3-inch flat steel bar and welded in place. The holes are drilled on three-inch centers. The guard unit shown is provided with a pair of

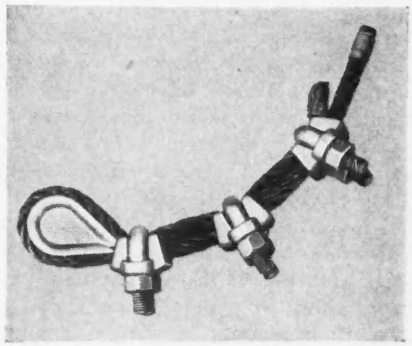


short angle iron legs bolted to the upper surface of the skid base. The top of the unit is held in place by a short length of the three-inch bar bolted to each side of the radiator at a point just below the top tank. As an aid to the mechanic when the radiator is filled or inspected, the welder made three ladder rungs of the same sucker rod material, welding one at each of the three horizontal bars.

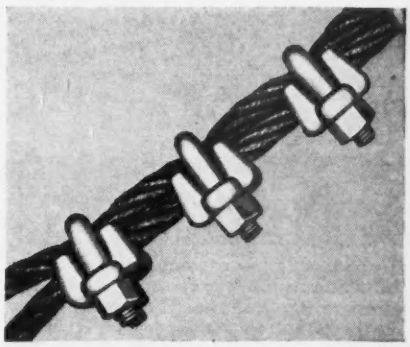
The guard unit is inexpensive to build, causes little or no impedance of the flow of air through the core and is capable of warding off heavy blows when pipe or other equipment may be bumped accidentally against the front of the radiator.

THIS PROVES

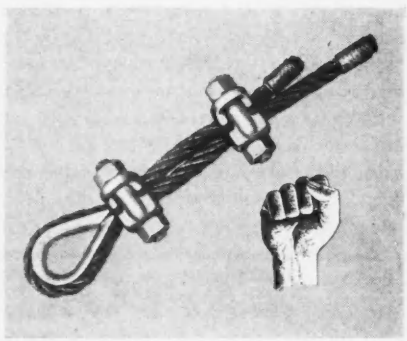
"Fist-Grip" Clips superior — see for yourself!



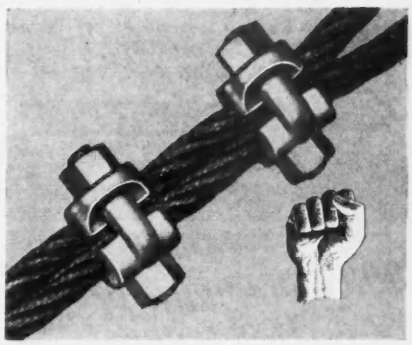
1. U-BOLT CLIPS crush rope into bowed shape when nuts are tightened. Weakened rope endangers safety.



2. CRUSHED ROPE is further damaged by U-bolt clips when rope is under tension. Note crimping.



3. "FIST-GRIP" CLIPS save rope, hold wire straight when clipped. There's no damage, no distortion with "Fist-Grip" Safety Clips.



4. STAYS STRAIGHT under tension. Efficient "Fist-Grip" Clips deliver 95% to 100% of rope's rated tensile strength.

Look to Laughlin for these "Fist-Grip" Clip benefits

Won't crimp or crush — pre-formed or regular lay wire rope; leaves them full strength for safety and longer life

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100% foolproof — can't be put on backward

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Extra strength and safety — only type clip where entire clip, including bolts, is drop-forged

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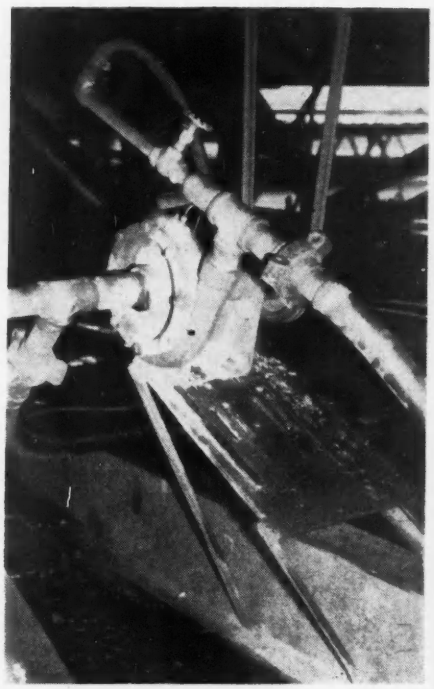
HOW TO—Mount Washdown Pump

A common method of mounting and driving the washdown pump is to set it up at a convenient point beneath the derrick floor and drive it with V-belts from a take-off in the transmission case immediately above it. One drilling contractor operating in the West Texas area has further improved this method of installing the pump by setting it on an inclined base, the latter being welded to any convenient part of the substructure and supported by angle iron legs as shown. The base plate is provided with slots which allow the pump to be moved downward as stretch or slack in the belts may demand. The relative small horizontal component of such shifts along the base plate does not affect the drive from the transmission case overhead.

Mounted in this manner, the pump readily can be removed or serviced and the belts tightened whenever necessary. In most instances, the pump can be left on the base while the rig is moved or skidded from one location to another.



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By GILBERT M. WILSON
Pacific Coast District Editor

Portable Tank Farm

For Gauging Wildcat Wells

THE successful completion of a wildcat, or even a development well some distance from existing trap and gauging facilities, frequently presents a tank and gauging problem to the production department. The problem usually is one of deciding—and quickly—whether to install temporary trap and tanks, knowing that this equipment ultimately may have to be replaced by permanent equipment, or whether to rush to completion a permanent tank farm, it being realized that any material change in production rate, possibility of the well's developing a high water cut or other changes, might mean costly modification of the installation.

The answer to this frequently-recurring problem may be found in the ingenious portable skid-mounted trap and tank farm shown in Figure 1, which was designed and recently placed in service by the Coastal Division of Shell Oil Company. With these portable test facilities, the company is able to put a new well on production immediately, producing it at a variety of rates and for as long a period as desired, until sufficient information is gathered to enable engineers to evaluate the well's performance. With this information they then are in a position to specify the proper type and capacity of traps, metering, storage and dehydration equipment, not only for the initial well but for other wells that subsequently may be drilled in that area. The portable tank farm can be installed at a well with little or no advance preparation or levelling of a site. Benefits to be derived from the prior use of the portable facilities include the need for only one grading operation to be performed, ability to accurately map out in advance the needs for trucking and installation of the permanent equipment, and the reasonable assurance that the equipment will not have to be changed or removed in a short while.

Skid Mounted

The portable test equipment consists essentially of two rectangular 250-barrel steel tanks mounted on skid bases. On a platform at the front end of Tank 1 is mounted the trap, meter run, shipping pump and most of the necessary piping. On a similar platform on the front of Tank 2 is carried a portable loading rack, this unit being removable for setting up wherever convenient at the well location. Each of the two tank units constitutes a "package" which conforms in every respect to California highway requirements when carried on a low-bed semi-trailer.

FIGURE 1 (Photo Above). View of the two units comprising the portable trap and tank farm as set up on a semi-exploratory well location. Each unit, hauled on a low-bed trailer, conforms to highway regulations. Each tank has 250-barrel capacity. Flexible hoses are used to connect overflow between tanks, for stack line (at left), sump and drain lines. Eyes welded to tops of tanks facilitate handling by portable cranes if necessary.

Over-all dimensions of each unit are as follows: width, 7 feet, 6 inches; length, 34 feet, 6 inches; and maximum height, 9 feet, 10 inches. Each unit, completely equipped and ready for hauling over the highway, weighs approximately 16,000 pounds. The skid base of each unit isi made up of three longitudinal members of 10-inch I-beam and 8 cross members of 6-inch I-beam material. The tanks are of all-welded construction and are internally braced and strengthened to withstand the type of service that comes with frequent moving and hauling in the field. Bottoms of the tanks are welded directly to the top of the skid base members so the units can be skidded without danger of injuring the underside of the tanks.

Tank bottoms are of one-fourth-inch carbon steel plate. The lower four feet of the sides is of 3/16-inch and the upper four feet is of ten-gauge steel. The six-inch crowned decking is of 12-gauge material. All structural supporting and bracing of the tanks is internal and consists principally of three-inch angle iron, channel section and one-inch steel tie rods. The three-inch angle iron is used at corners and along the top edges. The 3 x 1½-inch channel iron is run all the way around the side of the tank at the seam level. Six vertical supports of the same channel material

FIGURE 2. Close-up view of trap, meter run, shipping pump and other equipment mounted on platform of Tank 1 unit. Note compact arrangement and easy accessibility of equipment, sectionalized punched steel decking and thread protectors chained to fittings. Trap is securely guyed with three half-inch rods attached to special tie-down ring atop the upper sphere.

FIGURE 3. The portable loading rack is installed at any convenient place, either above or below level of the tank units. Flexible line from tanks, in background, connects into leg of rack which conducts oil up to loading spout. Electric shipping pump, equipped with pressure switch, delivers oil to loading rack, but in this particular instance it was by-passed as rack was at lower level.

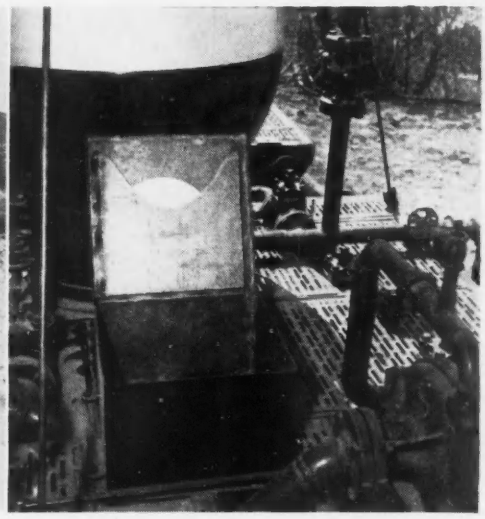


FIGURE 4. Large sheet metal box, in which is stored tools and spare fittings, also has special compartment built into inside cover for convenient storing of recording gas meter charts. Ears welded to the bottom edges of the box permit bolting it to the platform and subsequent easy removal of the unit if and when work is done on connections beneath the decking.

on each side of the tank provide additional stiffening of the tank shell. One-inch horizontal tie rods extend from side to side at each intersection of the longitudinal and vertical channels. The roof bow is supported by a 3-inch by 12-gauge carling which runs the length of the tank.

The tanks themselves are 25 feet, 6 inches long by 7 feet, 6 inches wide, and are 8 feet high. They were designed so that their capacity in barrels per inch of height would be approximately the same as that of a standard one-ring, API 250-barrel tank. Each tank is equipped with an 8-inch, 3-in-1 gauge hatch and a 3-inch pressure-vacuum relief valve. Two cleanout manholes are provided for each tank, a 16-inch round opening in the front end and a 28 - x - 38 - inch rectangular opening in the rear. An overflow line connects one tank to the other, but to provide for the possibility of both tanks filling while no one is in attendance, a three-inch overflow standpipe is built into Tank 1. Should overflow oil enter this standpipe, it will flow into the drain line and pass on through to the sump.

Trap and Metering Equipment

The platform at the end of each tank is eight feet wide and 7 feet, 6 inches long, and is decked over with perforated tank decking material. Installed in small sections, the decking easily is removed for access to the piping and manifold connections connecting the several pieces of gauging and metering equipment.

On the platform of Tank 1, (Figure 2), the largest single piece of equipment is the two-sphere, 220-pound working pressure separator. Incoming oil enters at the side of the upper sphere where the initial flash occurs. A secondary flash occurs when the oil enters the lower sphere which also is the float chamber. Separated gas emerges from the top of the separator, goes through a back-pressure regulator, which usually is held at about 50 pounds per square inch pressure, on through a three-inch gas meter run, then to a back pressure valve and on out to the stack line.

The separator is anchored with three ½-inch rods which attach to a specially-made tie-down ring set on the upper surface of the top sphere. The float lever arm on the lower sphere can be tied down so no damage can occur to the float or linkage during travel between wells.

Oil emerging from the separator from near the bottom of the lower sphere passes through an elevated two-way valve and on into the tank through a two-inch filling line. Oil can be switched from one tank to another through a two-inch flexible hose which connects the two tanks. The three-inch overflow line which connects the two tanks near the top also is of the flexible type. All flexible hose connections are of the fire hose type for easy, quick connecting and disconnecting in the field.

A gauger's stairway and platform, complete with guard railing, is mounted on the platform of Tank 2. A short gauging platform of similar width and construction, and placed at the same level, is mounted on the end of Tank 1. When the two tanks are set up side by side, a hinged steel platform section is dropped into place to connect the two gauging platforms. Short pipe spacers are installed at the skid base level to simplify the spacing and aligning of the two tank units.

Flexible Hose Connections

Remarkably little work is entailed in setting up and placing the portable units in service. At the location, tanks are skidded or hoisted into place on any convenient, reasonably level area of ground near the well, blocks being used to level the tanks if necessary. Generally, there is sufficient room near a well to allow trucks to back up into the location and skid the units into place, but for those instances in which loading cranes might have to be used in placing them, four reinforced lifting eyes are provided on the top of each tank. Although it is necessary that the units be level, it is not absolutely essential that they be on exactly the same plane, for the connecting hoses between the two tanks, being of the flexible type, allow for any slight misalignment that might exist. When the incoming oil line, drain and stack lines, all rubber hoses, are connected up, the unit is ready for operation. The loading rack is skidded to any convenient and safe place on the location, the hose is connected and the loading facilities then are ready for service.

Mounted on the platform beside the separator on Tank 1 unit is a direct-connected, electric motor-driven centrifugal shipping pump of 150 gal-

lons per minute capacity. It is driven by a three-horsepower electric motor and can use current supplied by the drilling rig generators, portable power generating units or purchased power if that is available. All electrical connections are mounted on a panel on the end of Tank 1. The motor and all electrical switches are of the explosion-proof type.

Portable Loading Rack

Included in the shipping pump and loading rack design is a safety and time-saving feature that greatly simplifies tank truck loading operations. A pressure switch, installed in the shipping pump discharge line, automatically shuts down the pump when the valve at the loading rack is shut off. This feature is particularly desirable when the loading rack may be out of sight of the tanks or when loading has to be done by only one man. In the particular installation discussed in this article, the loading rack was spotted on a level below that of the tanks and oil flowed by gravity, permitting the by-passing of the shipping pump.

The loading rack itself (Figure 3), is of all-welded construction and is made up principally of two-inch pipe material. Mounted on an I-beam skid base, the unit stands about eight feet high when the guard railing surrounding the 30 x 36-inch platform at the top is laid down flat. The guards are hinged along the lower edges, permitting them to be dropped down when the unit is to be moved. Oil, coming from the tank through the rubber discharge hose, enters through a connection in one of the rack legs. The counterweighted loading spout, connected with a quick-acting coupling, normally is carried on a special rack atop Tank 2 when the assembly is being transported from one location to another. The area inside the sucker rod railing at the base of the unit is used for carrying the coiled waste line and stack line hoses.

All-Weather Blackboard

Among other features of this portable tank farm is a small all-weather blackboard mounted on the front end of Tank 2. Test gauge data taken during the tour are jotted down on the inside back surface of this board. Illustrated in Figure 5, the board has a flanged cover, hinged at the top, which can be closed and made rainproof during periods of bad weather. Beside the separator on the front platform of Tank 1 is mounted a tool box of welded sheet steel in which can be carried spare fittings, tools and other equipment needed for setting up and operating the field units. The box (Figure 4), is bolted to the platform for easy removal if and when equipment or piping is to be overhauled or replaced. A compartment welded to the inside of the tool box cover provides storage for spare orifice meter charts. The tank gauge stick, carried on Tank 1 unit, is run through a two-inch pipe sleeve attached to the end of the gauger's platform and at the bottom, rests in a socket of the same material. As can be seen in the photographs, thread protectors attached to short lengths of chain are provided at each fitting that ordinarily would be left exposed when piping is disconnected preparatory to making a move to another location. Absence of burring or dirt in such pipe threads assures rapid making up of fittings when units are spotted at the new location.

Typical advantages to be realized through the use of this portable tank farm are to be found in the following example of a moving job that was done shortly after the units were placed in service. The two tank units were moved from one of the company's Ventura Avenue leases to the Dryden lease in the Bardsdale field, a distance of about 33 miles. At 8:15 a.m., a roustabout gang started disconnecting the units which had been connected to the flow line of a well and by 9:00 a.m., both units were loaded on the low-bed truck (Figure 6) and ready to be moved. In this particular instance it was necessary to use a crane for loading the tanks because of the difficult terrain on which the tanks had been located. By 10:30 a.m., after a 33-mile trip, the trucks arrived at the Dryden lease well site and were ready to be unloaded. The units were skidded off the trucks and set up on the sloping, ungraded location, unaided by a crane or other equipment other than the truck winches. After some blocking and leveling of the units, by 1:30 p.m., they were ready to be placed in operation.

The significant point in this operation is the fact that it was possible to install all of the necessary gauging and testing facilities for testing a semi-exploratory well in a total elapsed time of only 5½ hours. The cost of this operation was estimated to be about $350 and represented a saving of from $1500 to $2000 when compared to the cost entailed in the erection of conventional temporary tanks, trap and testing facilities. Such savings, repeated each time the units are placed in service, easily will offset, in a short time, the cost of designing and constructing the portable units.

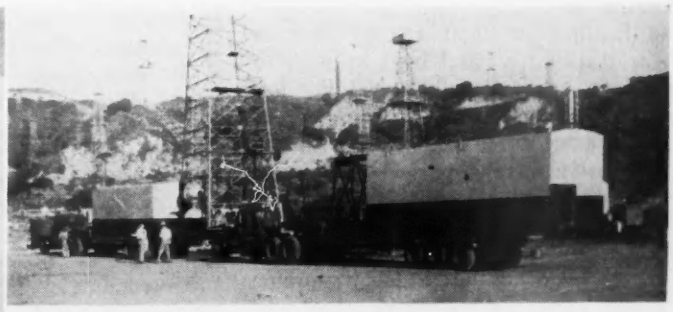


FIGURE 5. (Left) All-weather blackboard for recording gauges taken during a tour, shown in the open position, is mounted at a convenient level on front of Tank 2. Note manner in which gauging platforms of the tanks are joined by hinged platform section which is dropped into place after tanks are positioned and lines connected.

FIGURE 6 (Above). Shown here are both units loaded on low-bed semi-trailers ready for over-the-road travel. In this loading operation the tank units were disconnected from a well and loaded on the trucks in the short period of only 45 minutes. Note that the loading rack is carried on platform on the front of Tank 2 unit.

Electric HEATER Cuts Paraffin

By O. C. DUNN, JR.
Petroleum Engineer,
Marietta, Ohio

PARAFFIN, which retards the flow and seepage of oil into the well bore, has been an irritating problem to oil producers in most sections of the country. The problem is especially costly in stripper well areas where every barrel of production must be produced with a minimum of shut downs in order to make the operation economically profitable. The industry has resorted to various methods to remove paraffin or prevent its forming on the producing stratum such as the injection of steam, hot liquids and gases, heat producing chemicals, chemical solvents; open flame applied under fluid level in the well-bore; setting wells on fire in the producing formation; electric heating and other methods described in the U. S. Bureau of Mines Bulletin No. 348.

Depending on conditions, some methods have been fairly successful and others uneconomical. In some instances emulsions were formed which caused failure; in others, the improper application of heat caused bottom hole distillation, and heat applied to vacuum processed formations has sometimes sealed the producing zones and the wells have been abandoned.

Relatively speaking, one of the most successful methods of paraffin removal has been by the application of electric heat in the shot-hole of the well-bore. This method has been especially profitable in the Pennsylvania area and there is reason to expect similar uniform results in the Panhandle and other fields in the country where operators of marginal wells are plagued with paraffin obstruction. Wells subjected to this treatment had produced for many years and it may be reasonably assumed that the more volatile ends of the oil in place had been dissipated, allowing a more rapid precipitation of the paraffin deposits in crystal and wax form on the exposed surface of the producing formation.

Experiments with electric heat as applied by specially designed devices developed over a period of years took place mainly on leases in the Pennsylvania area under the Smith-Dunn method as described in the aforementioned bulletin. Initial experiments proved the method too costly, but it was favored because of satisfactory and uniform results. It was noted at the time that those wells successfully heated with electricity retained their increased production with an annual decrease of approximately 10 percent.

At first, exposed element type heaters were employed but were soon discarded due to the rapid corrosion of the element when current was applied with brine waters present. Replacement of the elements was necessary each time a well was heated. Although the elements were not prohibitive in cost, it was necessary to have skilled labor available to effect repairs when required and this, plus the time required for such replacement, nullified the advantage of this type electric heater.

THE AUTHOR investigates various types of down-the-hole heaters for freeing the sand face of paraffin accumulations, and recommends a type of device utilizing electric energy as heat source. Wells so treated are reported to maintain increased production over periods of time ample to justify the added workover cost.

Design Problem

The next step was the designing of an enclosed type, moisture-proof heating unit to lower through the tubing to the desired level on a self-supporting cable of the marine electric type. Several of these units were built and a substantial increased production was obtained, with wells in the Penn grade area responding from one-quarter and one-half barrel a day production to as high as 12 barrels per day settled production. Also, three wells heated in Oklahoma responded as follows: 7½ barrels to a maximum of 43½ barrels and settled one year later to 27½ barrels per day; 8½ barrels to a maximum of 27½ barrels and settled one year later to 18½ barrels per day; 12½ barrels to a maximum of 30 barrels and settled one year later to 17½ barrels per day. The term "settled production" is used because during the first day or so after a well is heated the production responds like a new well after shooting and produces more than the well would average during the succeeding years, having a flush production the first few days after heating.

The important facts observed during these experiments were as follows:

- Unless the tubing and rods were kept warm by a flow of electric current during the initial pumping of the well after heating, the fluid being pumped would congeal in the tubing as the fluid level was raised during the pumping process, cooling as it moved from the heated area.
- Compressed air for artificial flowing had the same cooling effect, espe-

cially in contact with the oil-bearing paraffin contacting the producing formation surface, and also the fact that compressed air which had to be preheated before flowing the well was not always available and a more satisfactory method of fluid removal was necessary.

●Considerable quantities of sand cavings fell into the shot-hole and pocket which demanded either a cleaning-out machine or a sandpump bailer.

●As the well retained its heat for for several days, sand-pump-bailing was found to be the most satisfactory method of removing cavings, paraffin and fluid.

●The crude oil pumped after such treatment was much cleaner and considerably more lively than prior to heating, and the stock tanks required little or no treatment before the oil was run by the pipe line company.

●After heat treatment the well did not have to be pulled for cup, ball, and seat replacement more than once a year as compared to monthly replacement of these parts prior to heating.

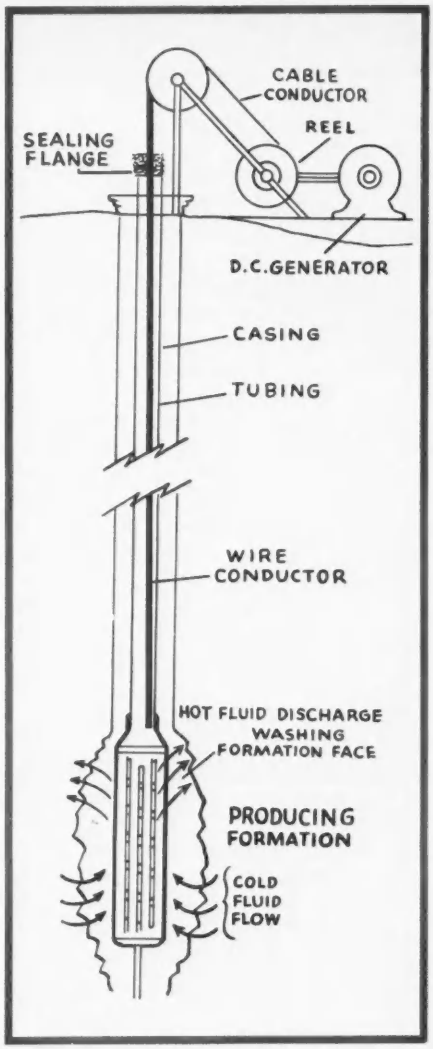
●The casinghead gas flow increased, both in richness and volume.

●The results were much more lasting than any of the other methods above mentioned, with electric heating giving definite results lasting from two to three (sometimes five) years as compared to three to five months response from other methods.

Due to sand caving during treatment it was apparent, especially in the loosely consolidated formations, that the limiting of the heater outside diameter size to that of less than the tubing was an unnecessary restriction and that the determining factor governing the outside diameter of the heating case was the smallest part of the well bore through which the heater could be lowered. This led to a new design of heating assembly which could be suspended at the proper level on the tubing. The expensive cable was eliminated and the heavier body of the heating unit became almost indestructible and definitely less costly than any of the former units.

Surface Equipment

Surface equipment and machinery consists of a portable generating outfit if public utility current is not available, a 36-inch reel (either power or manually operated), cable, a pulling winch to handle tubing and sandpump bailing, mast, and three men familiar with well maintenance. The heating unit, cable, and machinery with proper care should not require inspection or overhauling more than every 5000 hours.



The heating units built varied from 10 to 150 kilowatt-hour capacity. Conclusions indicated a minimum of 35,000 British thermal units per hour for each 20 feet of vertical exposed formation with a higher delivery dependent on the following conditions and factors: (1) the natural fluid flow into the well, oil, water, and gas; (2) static fluid level; (3) specific gravity of fluids; permeability, porosity, and specific gravity of producing stratum. The heating units used on the tests (Tables 1 and 2) generated approximately 3412 Btu's per kilowatt-hour delivery as based on the definition of the heat required to raise the temperature of one pound of water from 32° F. to 212° F.

A preliminary history shows the original producers operating in the Chesterhill field, Morgan County, Ohio, in the Pennsylvania grade area from the first Cow Run sandstone of the Coal Measures of the Carboniferous division and were also the first to initiate repressuring by artificial means with a belt driven compressor in 1911. A modern plant was installed in 1919 after several modifications had been made on the plant placed in operation. In October, 1933, efforts were made to find new means of maintaining production after the proration of the field was lifted. A program of well cleaning began, supplemented with chemical solvents and heat forming solutions. All the wells were cleaned and re-shot, and then received one or another of the chemical treatments. The response varied in each case with some of the wells giving no additional yield.

As some benefits had been derived in 1917 and 1918 by cleaning out and steaming, when heat and solvent chemicals were also tried without too much success, it was decided to operate the property to its economical limit. The methods mentioned were tried on both producing wells and those that had "gone dry," with the producing wells showing a fair increase but having no effect on the others except in one or two cases where the well would produce only during the period it was being steamed. Several wells were placed on the non-productive list due to improper placement of shot, and the assumption is that the wrong well records were used with the shot forcing the paraffin back into the producing formation or plastering the face of the exposed stratum formation. The fact that all air-gas flow as well as fluid seepage stopped seems to confirm this reasoning. Wells were not known by numbers and attempts were made to correlate well logs with casing points and bottom hole measurements while cleaning out.

Heating Employed

Chemical solvents were discarded in 1937 after being given an extensive test with most wells requiring retreatment within three months, although in some cases the period would be stretched to five and attempts were made to peel the paraffin from the exposed surface of the producing stratum. These methods were discarded, and as water-flooding was not feasible, abandonment of the oil producing wells was being considered in 1939. The method of electric heating was applied as a last resort. There follows a series of the tests conducted.

Lease 1 with three small wells producing and six non-producing wells were heated at this time. Each well was cleaned out and daily production was checked for one month prior to heating. The results are tabulated in Table 1.

The increase shown is from 11/42

of a barrel per day to 174 gallons or 4 6/42 barrels per day. This is not much considering well production in the Southwest, but in the Pennsylvania fields where wells are small with an average production of one-eighth of a barrel per day, the increase gains greater significance and is of considerable importance. The casinghead gas also increased in richness and volume, enabling the 20 horsepower gas pumping engines to operate without resort to the strictly gas producing wells. The amount of gas from the gas wells required by the gas engine driven compressor was reduced to 10,000 cubic feet per day (or 10M/24 hrs.) with the balance being sold to the utility gathering company.

On Lease 1, Well 8 had not produced any oil since 1931; Wells 17 and 19 made a very small production, and Well 3 went dry in 1928. These wells were heated with a light test as shown in Table 1, with 46 barrels of paraffin being removed from all the wells. A two months winter freeze-up causing compressor shutdown and pumping did not seem to affect the wells as soon as pressure was rebuilt in the formation. Daily average, as well as individual well production tests were made at least one week of the month.

It was necessary to replace a 15-barrel tank with two 65-barrel tanks and use the former small stock tank as receiver while one or the other tank was being run. Cooperating with the pipe line company, as their policy was not to run a tank of 65 barrels or less more than once a month, considerable difficulty was encountered in getting an actual production report. The wells would not head up more than one day's production, and a number of days shutin were required to get the well back on production due to water displacement. The Buckeye Pipeline Company cooperated to their fullest extent showing as much or more interest than the producers. At that time, not knowing what coming events might bring in the way of restriction, proration, price regulations, and other changes, it was deemed unwise to invest in new heavy duty equipment to carry on the tests until it was definite that the process would continue to yield the same results on wells over a varied section of the field. As the equipment was second-hand when purchased and had been rebuilt with several replacements during the test, it was evident that the generator would not hold up to a full load operation for the heating elements in use.

Reaction Tests

On the first four wells heated the generating unit was operated at maximum load. In each case the power unit burned out, so during the following year only two-thirds of the necessary kilowatt-hour current was delivered to the heating element. The balance of the wells tested was for reaction rather than results and to check the response towards increased production. Results are indicated in Table 2.

From the partial delivery tests conducted on Lease 2, the increase was from 1-1/7 to 10-5/42-barrels per day. The two last wells heated were subjected to more heat than the others and showed a considerable increase as will be noticed in Table 2. Twenty-five barrels of paraffin were removed from Well 7 during the two heat test runs, and 22 barrels from Well 8.

Power cost of the longest heating run shown in Table 2, based on local domestic rates, totaled $51.18, which would have been lower had commercial or industrial rates been available. Costs were arrived at as follows:

1st 30 KWHRS	.052c	$ 1.56
2d 40 KWHRS	.04	1.60
3rd 80 KWHRS	.03	2.40
Additional 2607	.0175	45.62
		$ 51.18

In order that the tables may be fully understood the writer wishes to point out that during the short delivery tests recorded in Table 1, there was a delivery of 15 kilowatt hours, or the equivalent of 51,180 Btu's per hour; while Table 2 shows tests made with a delivery of only 12 kwhrs, or 40,944 Btu's per hour. During the early tests made beginning in 1923, as high as 150 kwhr delivery was made and the heating delivery power was reduced to the minimum by gradual stages. It will also be noted in both tables that a maximum production is shown as well as settled production one year later. The average production one year later was made by individual well production measurement, and the flash response immediately after heating was as spontaneous as a new well being shot.

Reheating apparently is not necessary for a period of from two to five years, although wax precipitation starts as soon as the well cools off. However, the wells heated remained good commercial producers for at least three years before reheating was necessary.

Results obtained by the described method appear to hold promise for successfully combatting paraffin troubles in other fields where operators are confronted with the same problem. This application under suitable conditions would cut costs to a minimum, the frequent cleaning-out jobs, replacement of ball and seat valves and cups, the treatment of stock tanks for shipment, and result in more stock tank oil for the producer.

Table 1

Well No.	DAILY PRODUCTION PRIOR HEAT—GALLONS		DAILY MAXIMUM PRODUCTION AFTER HEATING		DAILY SETTLED PRODUCTION ONE YEAR LATER		Kilowatt Hours Delivery	Hours Heat Delivery	Oil Increase Gallons
	Oil	Water	Oil	Water	Oil	Water			
19	7	8	50	36	....	....	409	21	....
19*	16	10	86	36	47	36	713	72	40
17	3	27	13	36	....	....	524	53	....
17*	10	20	45	36	13	14	746	75	10
3	1	18	110	36	93	35	745	75	92
8	0	Considerable water	87	630	32	126	612	61	32
Total Oil	Before 11	....	....	....	....	....	....	....	After 174

* Reheated 30 days after first heating.

Table 2

Well No.	DAILY PRODUCTION PRIOR HEAT—GALLONS		DAILY MAXIMUM PRODUCTION AFTER HEATING		DAILY SETTLED PRODUCTION ONE YEAR LATER		Kilowatt Hours Delivery	Hours Heat Delivery	Oil Increase Gallons
	Oil	Water	Oil	Water	Oil	Water			
H3	4	90	68	140	36	68	680	68	33
H1	0	2160	120	1420	12	400	707	71	12
H2	0	1100	107	1390	20	32	625	61	18
H8	8	22	138	37	21	22	517	50	13
H28	6	20	76	41	19	32	645	65	13
H20	1	18	43	25	20	27	680	68	19
H25	7	23	33	23	16	21	536	53	9
H36	0	38	120	110	61	68	645	64	61
W8*	21	42	758	210	210	84	2757	229	202
W7	1	80	55	85	....	....	1700	221	....
W7	48	....	410	175	210	84	1500	209	209
Total	47	....	....	....	....	....	....	....	589

* Last well heated.

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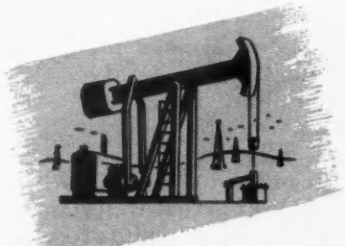

Are Your Lifting Costs High ON ABRASIVE WELLS?

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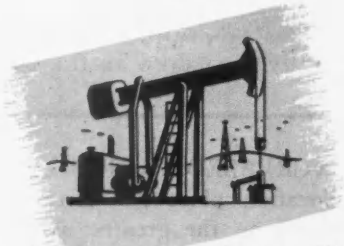

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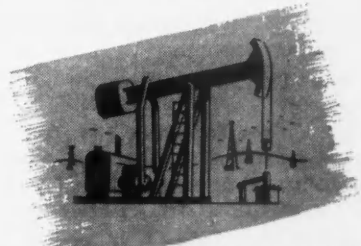

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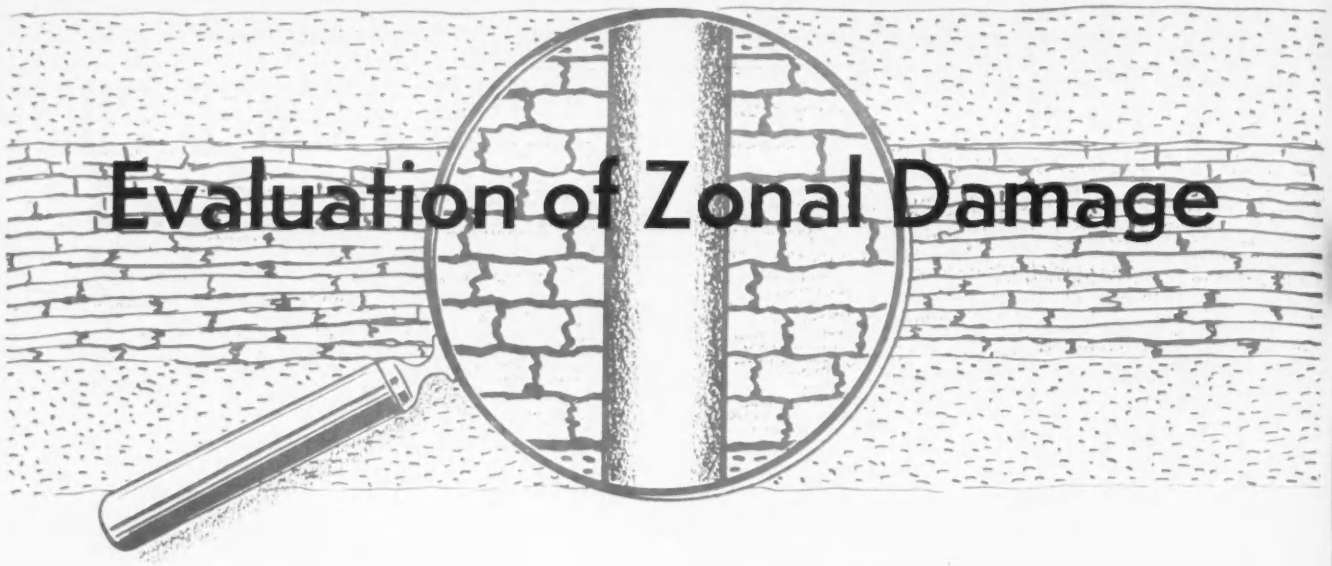

Evaluation of Zonal Damage

By NORRIS JOHNSTON and N. VAN WINGEN

Petroleum Technologists, Inc.
Montebello, Calif.

INCREASING demand for petroleum products is causing a rapid depletion of proven oil reserves. Much effort is being directed towards their replacement. Accordingly, exploration has been at a high level of activity for a number of years. As the more obvious and most accessible areas have been developed, the cost of finding new reserves has increased to a point approaching the region of diminishing economic returns. Accompanying the higher cost of exploration is the high production cost resulting from the generally greater depths of new discoveries and in some instances from the relative inaccessibility of the wells due to mountainous terrain or deep water location. As a result of this situation there is a growing emphasis on obtaining the greatest possible ultimate economic recovery from known reserves. Maximum economic ultimate returns depend mainly on (1) efficient utilization of native reservoir energy and/or its artificial augmentation such as by fluid injection; (2) attainment of a high degree of completion effectiveness; (3) maintenance of productivity indices at the highest possible level; and (4) low production costs and high product prices. The discussion to follow will be limited to those phases of the problem pertaining to completion effectiveness and productivity index maintenance.

Factors Affecting Productivity Index

In oil field practice the productive capacity of producing wells is generally measured as the rate of production per unit pressure drop. When expressed as barrels per day per pounds per square inch, this unit of measure is termed "the productivity index."[1,2,3] The productivity index can be defined theoretically in terms of the fluid properties, the dimensions of the flow system, and the effective permeability to oil. It is evident that such a definition applies directly only to steady state flow to which the behavior of actual wells can at best be but an approximation.[2] Thus, while the quantitative significance of the absolute magnitude of individual productivity index values may be in doubt, many applications of practical importance can be made of such data. For example, comparison of productivity index values for wells similar in characteristics except for the drilling fluids used will give a measure of their relative effectiveness with regard to the quality of completion. Likewise, the effectiveness of well repair or acid treatment can be evaluated by comparing productivity indices before and after the performance of such work. For certain areas the variation of productivity index with the sand permeability as determined by laboratory core analysis methods has been empirically established.[4,5] Significant deviation of any well's performance

INCREASED COSTS of exploration place growing emphasis on the greatest possible ultimate economic recovery from known reserves. Prevention of zonal damage and proper production procedures are important factors to be considered in order to achieve this objective. Zonal damage may occur in the course of drilling, redrilling and completing as a result of drilling fluid filtrate and/or particle invasion of the zone and poor quality mud cake. Available laboratory techniques make it possible to select at nominal cost an optimum completion procedure for any given set of conditions. There is, however, a need for research to improve methods and techniques for zonal completion.

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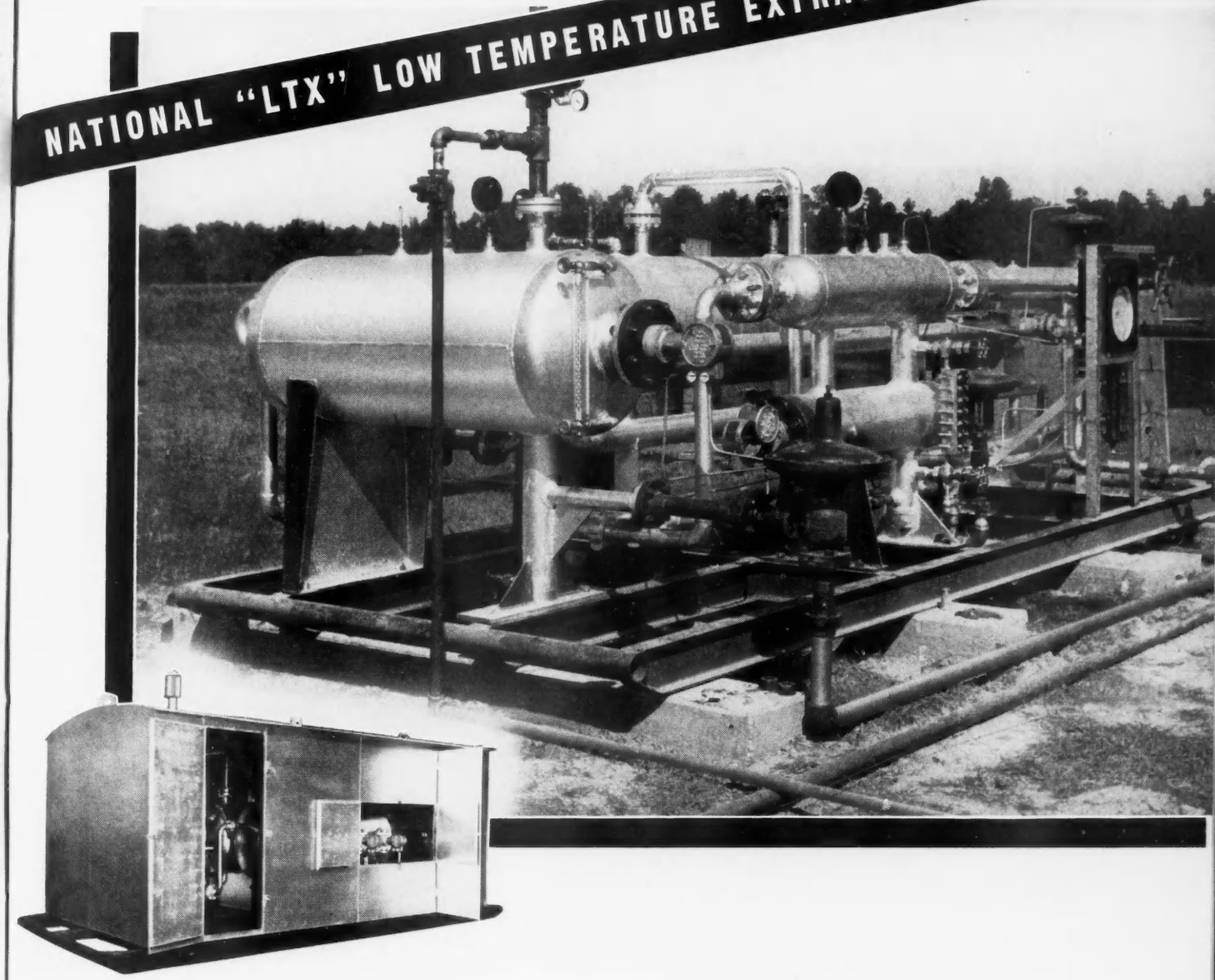

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from such a curve will be indicative of an abnormal condition such as a plugged liner, poor completion or a local anomaly of sand characteristics.

The productivity index of a well is influenced by numerous factors which can be divided into two categories; first, those determined by the physical and chemical properties of the reservoir and its contained fluids; and second, those dependent upon operator control of the well or well equipment. The first group contains the following:

1. Thickness, porosity and permeability of the reservoir rock.
2. Liquid and gaseous hydrocarbon and water content of the porous medium.
3. Reservoir pressure and temperature.
4. Nature, location and character of water zones
5. Pressure-volume-temperature characteristics of the hydrocarbons.

The second group includes:

1. Method of well completion.
   a. Acidization
   b. Shooting
   c. Gun perforating
   d. Liner design
2. Character of drilling mud used while completing well.
3. Production string design.
4. Well spacing and well diameter.

The character of the sand, its porosity, permeability and thickness, the extent to which it is saturated with oil, the physical properties of the oil, and the quantity of free gas which is associated with the oil are the important factors which control the pressure drop in the sand for a given rate of flow. Porosity and sand thickness, by controlling the area of the pore spaces through which oil may flow, fix the linear velocity which must be established to maintain a given rate of production. Permeability depends upon the effective or average diameter of the pore spaces, and hence, controls the pressure-gradient which is required to maintain a certain velocity of flow.

The physical properties of the oil influence pressure losses in a similar manner. Lower viscosity of oil permits higher rates of flow. An accurate determination of viscosity is important, not only at original reservoir conditions but also at pressures below the saturation or original reservoir pressure.

Formation-Volume Factor

The formation-volume factor, or the volume that a barrel of stock tank oil occupies in the reservoir, enters into the calculation of net oil produced. A higher formation-volume factor indicates that more oil with gas in solution must flow from the reservoir to produce a barrel of net tank oil at the surface. An additional factor which deserves consideration is the volume of free gas flowing to the well bore. This gas must occupy a considerable portion of the space between the sand grains, thus reducing the void space through which oil may flow, which in turn influences the pressure differential existing between the well bore and the surrounding formation.

From a consideration of the factors affecting productivity index which are under the operator's control, it is evident that these can be divided into two general classifications: 1, those which primarily affect sand permeability; and 2, mechanical equipment.

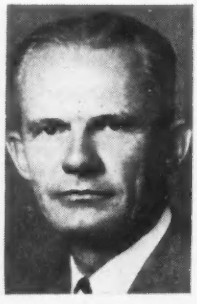
A. *Factors affecting average sand permeability:*

The over-all average permeability of a well's drainage area is a function of numerous variables. The relative importance of these can best be visualized by dividing the well's flow system into various regions as follows:

1. Undisturbed reservoir region.
2. Filtrate invasion region.
3. Particle invasion region.
4. Wall of bore hole.
5. Mud cake.

1. RESERVOIR REGION. The reservoir region is that portion of a well's drainage system which has not been affected by the drilling operations and which has thus remained undisturbed in its native state. The permeability to oil in this region is a function of the oil saturation which in turn is initially beyond the control of the operator. The changes which occur in the system, however, as depletion takes place are to a certain extent subject to control. Thus, high drawdowns and rapid rates of production entail dissipation of reservoir pressure with an attendant increase in oil viscosity and shrinkage and a rapid increase in gas saturation throughout the reservoir. The latter condition arises when solution

About the Authors



NORRIS JOHNSTON, president, Petroleum Technologists, Inc., consultants, Montebello, Calif., is a graduate of Massachusetts Institute of Technology and holds advanced degrees from that institution as wells as a Ph.D. from California Institute of Technology. His oil industry experience has been widespread and includes ten years with General Petroleum Corporation as chief physicist in charge of production research. During this period he was assigned for one year to Socony-Vacuum Oil Company to set up its Dallas Production Research laboratories. He has been active in API committee work and has contributed extensively to the petroleum literature.

N. VAN WINGEN, vice president, Petroleum Technologists, Inc., Montebello, Calif., is a graduate of California Institute of Technology and holds an M.S. degree from the University of California. His petroleum experience extends over 17 years and ranges from roustabout to chief evaluation engineer with Richfield Oil Corporation. From 1947-49 he was professor of petroleum engineering, University of Oklahoma. He has been active in API and AIME work, holding numerous national offices in both organizations, and has contributed extensively to the petroleum literature. He is a member of the Society of the Sigma Xi, Pi Epsilon Tau, AIME, and is a licensed professional petroleum engineer.

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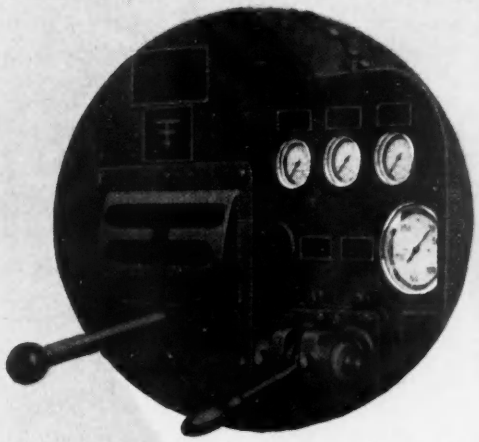

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gas is liberated too rapidly to allow it to separate from the oil and to migrate upstructure in accordance with gravitational forces. Instead, it remains entrained in the oil and hence dispersed throughout the drainage area, thus facilitating its production with an attendant waste of reservoir energy. The presence of free gas also reduces the permeability to oil by reducing the oil saturation. Even though lower drawdowns will improve producing gas-oil ratios because of a more favorable gas saturation distribution within the sand, reduction of pressure, and hence liberation of solution gas will occur as oil is produced, unless the native reservoir energy is simultaneously augmented by fluid injection.

2. FILTRATE INVASION REGION. In the filtrate invasion region original reservoir conditions have been disturbed by the intrusion of drilling fluid filtrates. The effect of this liquid incursion may be twofold in that in addition to its saturation effect, the liquid may interact with the rock structure. In either event the presence of the foreign liquid will cause a reduction of the sand's permeability to oil. It is to be noted, however, that in many instances the reduction of the native oil saturation due alone to the presence of the filtrate (no interaction with the rock structure) is a relatively temporary one as the filtrate often can be displaced into the well bore as production is started, unless zonal pressures are so low that the available pressure gradient may be insufficient to cause flow.

Fluid-Sand Interaction

In certain sands, interaction between fluid and sand occurs with a consequent reduction of the sand's ability to transmit fluids. A typical oil field example of such action is the swelling of hydratable clays by water. For such sands, the permeability as measured by air for a dried sample will be greater than the value established using formation water. Since connate water is present in virtually all known oil sands, it is evident that for such sands the formation water permeability will give a closer indication than will dry air, of the zone's ability to yield hydrocarbons.[6,7]

In the event the drilling fluid filtrate should further hydrate the clay material in the sand, it is evident that a further reduction of permeability will result and that such damage will in general permanently reduce the zone's ability to yield hydrocarbons.

From the preceding discussion it is evident that when the nature of the pore structure and the filtrate are such that interaction occurs, every effort should be made to prevent or at least minimize this occurence. This can be accomplished by a number of means. Thus, a reduction of the total time of exposure of the zone to the drilling fluid has been found to reduce contamination damage[8,9] as have chemical and physical treatments of the mud for the purpose of reducing fluid loss. Better than either of these, however, is the use of special muds such as oil-base drilling fluids whose filtrate (if any) will not interact with the porous rock. Still better, though economically not feasible, is reduced pressure drilling. Since the use of special drilling fluids as well as pressure drilling entail added expense it evidently is desirable to ascertain whether the nature of the sand being developed is such as to warrant the increased expenditure. While this could be done by actual field demonstration, other variables such as fishing jobs or changes in the lithological characteristics of the sand may be such as to obscure comparison. Also, the laboratory work costs but a small fraction of the cost of a formation test. Accordingly, it is generally more desirable to resort to a laboratory investigation where the permeability of core samples to the various fluids can be readily determined.

When the water filtrate from a fresh-water-base clay mud does cause hydration of clays present in the oil sand, these swelled clay particles may plug pore channels directly, or they may break loose from their attachment to sand grains and roll along pore channels until they find a constriction they cannot pass through. This ball-valve action causes partial plugging of the sand which results in loss of well productivity. It has been shown in the laboratory that after such a reduction in permeability, a reversal of flow will frequently cause a temporary improvement in flow rate, allowed by the unseating of some of the particles, followed by subsequent seating again in other constrictions in the opposite direction. This type of plugging is very serious, as it can be so complete as to render a good oil sand economically non-productive. The swelling of clays in an oil sand depends on both the mineralogical nature of the clays and of the electrolytes and their concentration in the interstitial water and the filtrate. Some of the major considerations favoring increased hydration are as follows:

a. Sodium clays swell more than calcium clays and these more than hydrogen or acid clays. Calcium clays occur quite commonly in oil sands.

b. Fresh water hydrates a clay more than salt water.

c. Clays can be changed as to their metallic ion content (base exchange) by soaking in water containing salts.

Completion Factors

As a result of the above and a number of less important facts, we find the following things likely to happen during completion of an oil well:

1. In an argillaceous sand (one containing hydratable clays) invasion of fresh-water filtrate may very effectively plug the sand.

2. In such a sand, invasion of sodium chloride water will cause far less swelling than would fresh water, but base exchange will be favored, changing calcium clays over into sodium clays, so that any subsequent invasion of the sands by fresher water will cause worse plugging than if the salt-water wash had not been made.

3. In such a sand, invasion of a calcium chloride water should cause still less swelling, nor will adverse base exchange be caused, but there are several cases on record where poor productivity resulted, possibly because of the formation of calcium precipitates.

4. In such a sand invasion by any fluid other than oil is dangerous. The filtrate from oil emulsion muds is aqueous, and not oil, though the fluid loss is usually much less than for ordinary water clay muds.

It is evident that all the various factors enumerated above lend themselves to ready analysis in the laboratory in that the seriousness of clay hydration plugging can be

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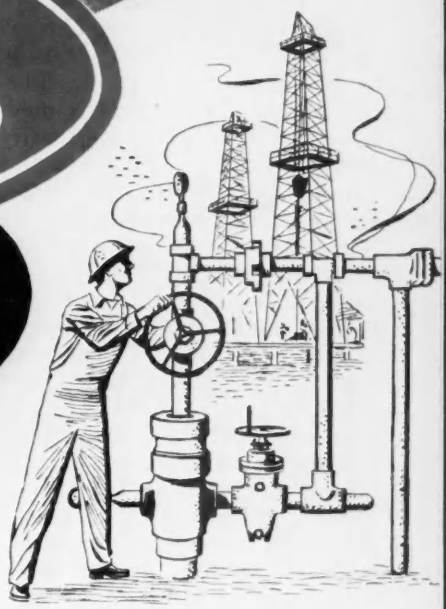

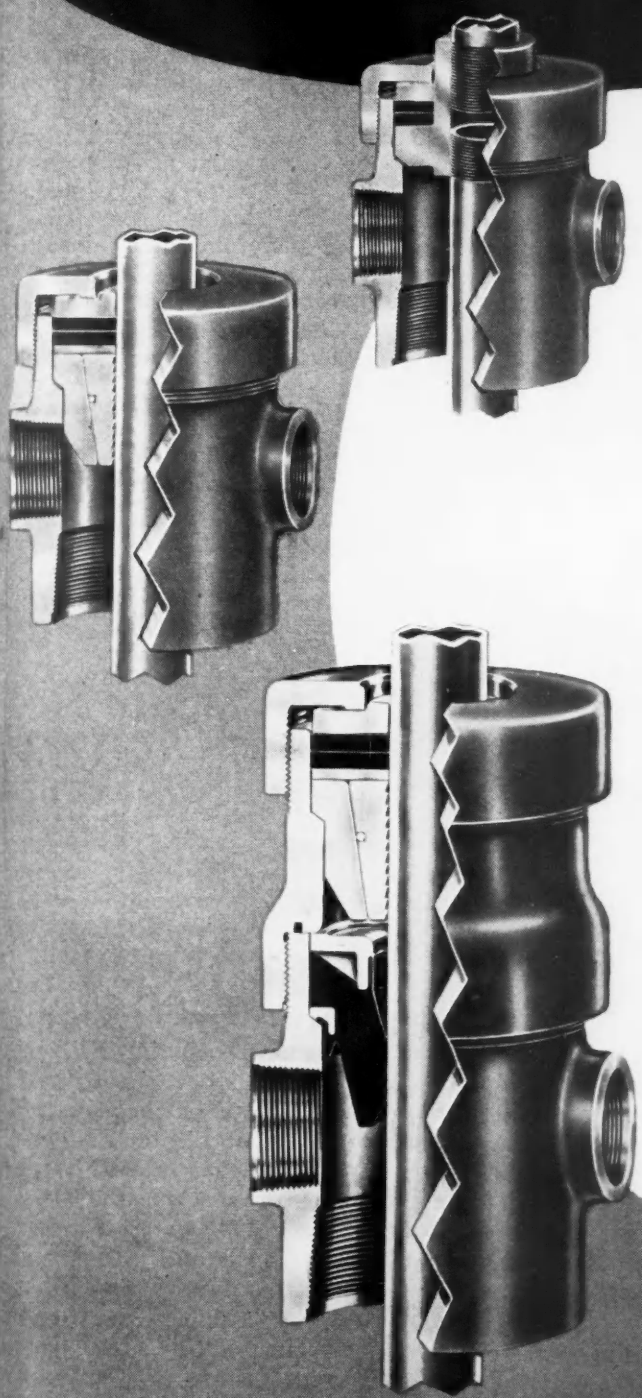

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measured by flowing the brine or filtrate itself in the presence of which the hydration occurs through a sand sample. It is also possible to replace part of the aqueous medium by oil and then measure the severity of the plugging by its interference with the flow of oil. The replacement of the aqueous medium by oil should leave a quantity of water equal to the equilibrium value, whether the replacement is by the restored state (capillary) process, or by the mere flow of oil (dynamic process). In either case the swelled and/or floating clay particles are present and plug some of the pore channel constrictions and in either case a lower permeability will result. It has been found in the majority of cases that although the exact magnitude of plugging as shown by the single phase test may differ from that shown by the 2-phase flow test, the order of magnitude and thus the final decision as to choice of drilling fluid is usually the same.

It has generally been found that while the permeability determined with a brine such as the native formation water is less than the air permeability, filtrates and fresh water will give progressively even lower permeabilities. Certain exceptions to this relationship have been encountered, however, in that occasionally a sand is found where the fresh-water damage is less than that of the filtrate of a highly treated water-base clay mud. For such a sand the use of an untreated water-base fluid is obviously to be preferred even though its water loss will be higher than that of a treated mud. Of course, when laboratory tests indicate extensive permeability damage to result from any of the aqueous fluids (filtrate or fresh water), use of an oil-base mud is indicated.

Particle Invasion

3. PARTICLE INVASION REGION. The particle invasion region is that portion of a well's drainage area (generally in the near vicinity of the well bore) which has been invaded not only by the drilling fluid filtrate, but also by colloidal and/or solid particles or plastic materials. Thus, depending upon the kind of mud being used, plugging of the sand may be caused by clays, barites, carbonates, starch, asphalt, or emulsion. Again, while such damage may be in part reversible under certain favorable conditions, necessary pressure gradients may be insufficient to effect removal, in which event the damage to the permeability will be permanent. The only effective means of preventing the occurrence of this plugging phenomenon is to choose and control the mud to assure a proper particle size distribution so that bridging action at the sand face will take place. Laboratory flow tests have been found to be helpful for the purpose of making up such a properly balanced mud.

4. WALL OF BORE HOLE. The face of the sand at the wall of the bore hole is subject to considerable alteration due to the mechanical action of bit and/or reamer. This crushing of the sand surface will not, in general, present a serious impediment to flow. The previously discussed factors of drilling fluid filtrate and particle invasion will, of course, also be effective in this region. In addition, because of its immediate proximity to the drilling fluid, increased saturation will take place in this region by imbibition of the mud filtrate. This latter effect, however, is generally reversible as this fluid will readily be displaced when the well is brought on production, unless formation pressures are exceedingly low. It is evident then that this region is subject to essentially the same damaging factor as have been discussed for the filtrate and particle invasion regions, and hence that the same preventive measures as have been discussed are applicable here.

Hole size may also, in many instances, affect productive capacity, even though it can be shown theoretically from a fluid mechanics standpoint that variation in hole size alone does not appreciably affect the total production rate. Thus, a well diameter increase from 3 inches to 11.2 feet is necessary in order to double the production rate in a typical oil well. The fact that actual performance deviates from the theoretical is largely attributable to mechanical factors. It is for this reason that wells often are reamed. Shooting and acidizing also are resorted to in order to increase hole size. These latter factors also have an important secondary effect, of course, in opening cracks or fissures when these are present as may be the case in fractured limestone, dolomite, shale, or conglomerate.

5. MUD CAKE. In the course of drilling, a mud cake on the walls of the hole serves the important function of supporting the formation so that it will not slough in on the drill pipe. Equally important, however, is the need for ease of removal of this mud cake from the wall when the well is put on production as otherwise it will offer serious resistance to the flow of oil and gas. The mud removal problem is especially important in low pressure sands, as when pressures are high a sufficient pressure gradient can generally be developed to remove the mud sheath. It is evident that the use of a mud with low filtrate loss, which forms a thin weak cake, will minimize the subsequent removal problem. This type of mud cake also has the added advantage that it will have a lesser tendency to plug the liner after it has been removed from the sand face. In order to predict whether cake difficulties are likely to occur, certain standard laboratory mud tests have been developed. Additional flow tests on core samples are also helpful in determining what pressure gradients will be required to remove a given mud cake.

Mechanical Factors

B. *Mechanical Well Equipment*

Mechanical factors which may significantly affect well productivity are:

1. The liner.
2. The subsurface production equipment.

1. LINER PERFORATIONS. The prime function of a liner is to exclude sand from the well while permitting oil and gas to enter; thus, perforations have to be designed to accomplish this dual purpose. To achieve maximum productive capacity, the percentage of the liner surface which is perforated should be a maximum consistent with structural strength. On the other hand individual perforations should be sufficiently small to permit the sand to form a natural bridge so that it will be excluded. This latter factor can best be established on the basis of the results obtained from laboratory screen analysis studies. It is evident then that even the best designed liner will offer resistance to the flow of oil due to convergence of flow as fluid movement is directed through the perforations.[10,11,12] In addition, liner perforations are known to be subject

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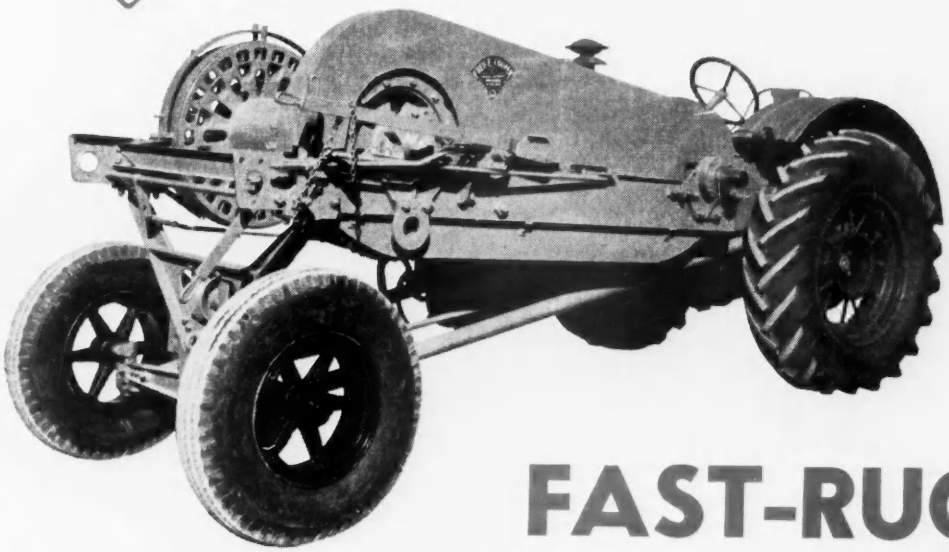

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to plugging. This will occur first as the liner is run into the well as it is scraped along the walls of the bore hole. Secondly, progressive plugging may occur as production takes place due to the selective movement of fines in the sand or due to the deposition of calcareous precipitates, paraffins, bitumens, or asphaltines. A complete prevention of perforation plugging as the liner is run in the hole is impossible to achieve although a good quality mud and centering guides have been helpful. Also, the use of scratchers will be instrumental in breaking up the mud cake so it can be circulated out of the hole before the liner is hung. Of course, this will still allow the perforations to become plugged with the formation sand and shale although these, being generally more competent than the mud cake, will have a correspondingly lesser tendency to cause liner plugging. In some instances successful results have been obtained by temporarily covering the perforation or filling them with a material such as sulphur while the liner is being run, which subsequently can be removed by acidization or string shooting after the liner has been hung. Liner washing and mechanical opening devices are other measures which can be used to open plugged perforations.

Liner Plugging

In certain areas the progressive plugging of liners as production proceeds causes serious loss of well productivity, necessitating periodic costly clean-out operations and even re-drills when plugging is so severe that washing, acidizing and mechanical opening devices are ineffective.

Laboratory flow tests of liner sections and laboratory studies to determine the type and source of plugging materials in sections of liners which have been removed from wells can offer valuable assistance in planning means to overcome these difficulties. One successful application of the results of such laboratory studies to a practical problem was the reverse circulation of hot, clean oil which resulted in the elimination of asphaltine plugging in a well where previously much trouble has been encountered due to loss of well productivity.

2. PRODUCTION EQUIPMENT. Production equipment for artificial lifting, either pumping or gas lift, of a size theoretically adequate to handle the potential productive capacity of a well, may still fail to perform satisfactorily due to inefficiency resulting from unforeseen circumstances. Thus, an improperly designed gas anchor will result in a serious loss of well productivity as the presence of gas will greatly reduce the volumetric efficiency of a pump. Likewise, when gas lifting in low pressure and/or high productivity index sands, serious loss of productive ability will result when packers are not used so as to eliminate back pressure on the zone.

Laboratory Procedures and Research

Currently available routine laboratory procedures are not, in many instances, being used to optimum advantage, largely because of lack of proper liaison between operating, engineering, and laboratory departments. Accordingly considerable additional improvements in over-all well performance could be achieved from a full application of present knowledge and methods. In addition to the benefits to be reaped from a systematic and meaningful application of applied laboratory work, there is much yet to be gained from further fundamental research for the purpose of gaining a better insight into the problems of fluid displacement. Drilling and completion techniques appear to offer an especially lucrative field for further improvement because of the direct control the oil producer can exercise over this phase of operations.

Economic Considerations

It has been developed previously that zonal damage is generally confined to a relatively restricted area in the vicinity of the well bore. Thus, the local reduction in permeability will not affect the ultimate recovery expectancy to the same extent as if the entire zone had been similarly reduced in permeability. A deleterious effect is definitely indicated, however, in that the lower productive ability of the well will prolong the time period necessary to recover the oil, with an attendant increase in lifting costs and that the economic limit will be reached sooner, thus leaving otherwise recoverable oil in the undamaged portion of the sand.[13] Accordingly, the small added cost entailed in evaluating and improving techniques is generally offset many times over by the increased recovery. In addition, it should be emphasized that even extensive laboratory work and the use of special mud together cost but an insignificant fraction of the total well cost. Certain phases of zonal damage which have occurred in the process of completion are subject to subsequent remedial procedures. Thus, as discussed above, successful results have been obtained with well washes or mechanical cleaning devices. It is to be noted, however, that these are generally most effective only in removing mud cake or in opening plugged perforations and that damage due to clay hydration is generally irreversible. Thus, it is evident that an avoidance of completion damage is much to be preferred to a poor completion, with subsequent attempts at recuperation, particularly so if the economics are also considered, as even a successful recuperation will generally show a much smaller profit margin than it is possible to achieve by an optimum initial completion.

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By K. D. SAUNDERS
Department of Engineering Mechanics, Purdue University

and A. D. TOPPING
Department of Theoretical and Applied Mechanics, University of Illinois

THERMAL STRESSES

Around an Uncased Hole

Part 1

THE collapse and failure by sudden rupture, excessive deformation, or plastic flow of the naked wall in a drilled hole during drilling operations and after completion of a well, has directed attention to the strength of the wall of the well and to the state of stress existent there. Miles and Topping[1,2] have reported on the problem and Westergaard[3] has also considered the state of stress around a deep well. The treatment is to consider the well as a thick-walled cylinder of inner radius a, and outer radius b, (b approaching an extreme), with a hydrostatic pressure acting at the inner surface and a compressive load in the vertical (z) direction due to the burden of the overlying formations.

In addition to these stresses, there exist during the drilling stage thermal stresses due to the difference between the temperature of the circulating fluid and the temperature of the formation. It is the problem of thermal stresses in the uncased formation hole with which this paper is concerned.

The Conduction Equation

Consider an element (Figure 1) bounded by horizontal planes z and $z+dz$, and by cylinders r and $r+dr$. Let the element be z units below the surface of the earth, and let the flow of heat be in the radial direction only. That is, let the assumption be made that

$$\frac{\partial W(z, r, t)}{\partial z} = 0.$$

(A description of the symbols is given at the end of this section of the article under the heading, **Notation**.) Since the gradient in the z direction is negligible,[4] say 1° F. per 50 feet increase in depth, these assumptions satisfy the conditions of the problem. For the case of Figure 1, a heat balance yields the relation

$$\frac{\partial q}{\partial r} dr = q_s \qquad \text{Equation (1)}$$

According to the laws of heat conduction and storage,

$$q = 2\pi\, rdz\, k\, \frac{\partial w(r, t)}{\partial r}$$

$$q_s = 2\pi\, rdzdr\, c\rho\, \frac{\partial W(r, t)}{\partial t} \qquad \text{Equation (2)}$$

From (1) and (2) it follows that

$$\frac{\partial}{\partial r}\left(r\, \frac{\partial W(r, t)}{\partial r} \right) = c\rho r\, \frac{\partial W(r, t)}{\partial t} \qquad \text{Equation (3)}$$

Differentiating and collecting terms and putting

$$\alpha = \frac{k}{c\rho}$$

, equation (3) becomes

$$\frac{\partial W(r, t)}{\partial t} = \alpha\left(\frac{\partial^2 W(r, t)}{\partial r^2} + \frac{1}{r}\, \frac{\partial W(r, t)}{\partial r} \right) \qquad \text{Equation (4)}$$

For the case of steady state, which involves constant boundary conditions, the usual method of solution of (4) is to assume W(r, t) composed of the transient and steady states and that it is a function of t alone multiplied by a function of r alone. That is,

$$W(r, t) = W(r, t)_{steady} + W(r, t)_{transient}$$

and

$$W(r, t) = T(t)R(r) \qquad \text{Equation (5)}$$

This type of solution is given in numerous books; for example, Reddick and Miller,[5] Churchill,[6,7] and Bowman.[8] For the case of variable boundary conditions, that is, when the boundary condition at z is F(t), a function of time, methods other than (5) must be sought.

The method of solution introduced by Heaviside and extended by others, now called operational calculus or the method of the Laplace transform, offers a direct approach to the solution of the conduction equation with constant boundary conditions, and is a method which works very well for variable boundary conditions if a mathematical trick is employed. For completeness, it is now necessary to introduce, and in some cases formally to develop, the necessary consequences and extensions of the Laplace transform and the Cauchy integral theorem of the complex function. For this, see Knopp,[9] Churchill,[7] Carslaw and Jaeger,[10] and others.

Properties of the Laplace Transform in the Complex Domain

Let s be the complex number $(x+iy)$ and let $\bar{w}(r, s)$ denote the Laplace transform of W(r,t). That is, let the operation

$$L\left[W(r,t) \right] = \int_0^\infty e^{-st} W(r,t)\, dt = \bar{w}(r,s) \qquad \text{Equation (6)}$$

define the Laplace transform of W(r,t) with s complex. In addition, let the

function $W(r,t)$ be continuous and of exponential order for $t \geq O$. That is, let

$$W(r,t) \leq Me^{x_o t}$$

Equation (7)

It is possible to show that $\bar{w}(r,s)$ is analytic in the half plane $\gamma > x_o$. From (6),

$$\bar{w}(r,s) = \int_o^\infty e^{-(x+iy)t} W(r,t)dt$$

$$= \int_o^\infty e^{-xt}(\cos yt - i \sin yt) W(r,t)dt$$

Equation (8)

The real and imaginary parts of (8) are respectively

$$u(x,y) = \int_o^\infty e^{-xt} \cos yt \, W(r,t)dt$$

and

$$iv(x,y) = \int_o^\infty e^{-xt} i \sin yt \, W(r,t)dt$$

Equation (9)

Now, it is well-known[5, 10, 31] that the necessary and sufficient condition that some function of x and y, say for instance $F = u(x,y) + iv(x,y)$, be analytic in the complex plane is that the Cauchy-Riemann conditions exist and are satisfied. That is, $\bar{w}(r,s)$ is analytic provided that, in (9),

$$\frac{\partial u(x,y)}{\partial x} = \frac{\partial v(x,y)}{\partial y}$$

and

$$\frac{\partial u(x,y)}{\partial y} = -\frac{\partial v(x,y)}{\partial x}$$

Equation (10)

It is readily verified that (9) satisfies (10) provided $x > x_o$, or, in other words, provided $e^{-(x-x_o)t}$ is bounded for $t \geq 0$. It follows that the consequences and extensions of the Cauchy integral theorem and integral formula apply to the transformed function, $\bar{w}(r,s)$, in the half plane $\gamma > x_o$. Continuity and differentiability are assured, and most important, the fundamental theorem of the theory of functions is satisfied for $\bar{w}(r,s)$, analytic in the half plane $\gamma > x_o$. It immediately follows that

$$\int_G \bar{w}(r,s)\, ds = 0$$

Equation (11)

with $w(r,s)$ analytic in G. An important consequence of (11) is the Cauchy integral formula.

Let $\bar{w}(r,s)$ be analytic in G, and put $s = \zeta$ on some path g in G, and let s be an interior point belonging entirely to G; then

$$w(r,s) = \frac{1}{2\pi i} \int_g \frac{\bar{w}(r,\zeta)}{\zeta - s} d\zeta$$

Equation (12)

It is next necessary to evaluate $\bar{w}(r,s)$. From (12) it follows upon integration along the half circle radius B and the line formed by the real part of ζ, $\zeta = \gamma$ (Figure 2), that

$$\bar{w}(r,s) = \frac{1}{2\pi i}\left[\int_c \frac{\bar{w}(r,\zeta)}{\zeta - s} d\zeta + \int_{\gamma - iB}^{\gamma + iB} \frac{\bar{w}(r,\zeta)}{\zeta - s} d\zeta\right]$$

Equation (13)

The absolute value of the first integral is less than $\bar{w}(r,s)\pi$ and has the limit 0 as $B \to \infty$. Thus

$$\bar{w}(r,s) = -\frac{1}{2\pi i} \operatorname*{Lim}_{B \to \infty} \int_{\gamma - iB}^{\gamma + iB} \bar{w}(r,\zeta) d\zeta$$

Equation (14)

The inverse transform of (14) is

$$L^{-1}\left[\bar{w}(r,s)\right] = W(r,t) = \frac{1}{2\pi i} \operatorname*{Lim}_{B \to \infty} \int_{\gamma - iB}^{\gamma + iB} \bar{w}(r,\zeta)\, L^{-1} \frac{1}{s - \zeta} d\zeta$$

Equation (15)

where $W(r,t)$ is the temperature function. Whence

$$W(r,t) = \frac{1}{2\pi i} \operatorname*{Lim}_{B \to \infty} \int_{\gamma - iB}^{\gamma + iB} \bar{w}(r,\zeta)\, e^{\zeta t} d\zeta$$

Equation (16)

Solution of the Conduction Equation with $W(a,t) = W(a)$, a Constant

Consider the plane, z, initially ($t \leq 0$) at formation temperature $W(z)$, holding z constant. Let $t = 0$ correspond to the penetration of this plane by a drill bit moving downward with some velocity and forming a hole of circular cross-section with radius a. Let the exit temperature of the drilling fluid as it is discharged against the face of the wall be $W(a,t)$. The temperature distribution at any time $t > 0$ is dependent on equation (4) and upon the initial and boundary conditions.

Let the initial and boundary conditions be

$$W(r,0) = W(z)$$
$$W(a,t) = W(a)$$
$$W(\infty,t) \text{ bounded}$$

Equation (17)

and let the differential equation be (4). The transform operation on (4) is

$$\int_o^\infty e^{-st} \frac{\partial W(r,t)}{\partial t} dt = \alpha \int_o^\infty e^{-st}\left[\frac{\partial^2 W(r,t)}{\partial r^2} + \frac{1}{r}\frac{\partial W(r,t)}{\partial r}\right]$$

Equation (18)

The direct integration of the right side of (18) and integration by parts of the left side, with $W(r,0) = W(z)$, yields

$$-W(z) + s\bar{w}(r,s) = \alpha\left[\frac{\partial^2 \bar{w}(r,s)}{\partial r^2} + \frac{1}{r}\frac{\partial \bar{w}(r,s)}{\partial r}\right]$$

or

$$\frac{d^2\bar{w}(r,s)}{dr^2} + \frac{1}{r}\frac{d\bar{w}(r,s)}{dr} - \frac{s\bar{w}(r,s)}{\alpha} = -\frac{W(z)}{\alpha}$$

Equation (19)

The particular solution of (19) is

$$\bar{w}(r,s)_p = \frac{W(z)}{s}$$

Equation (20)

while the complementary solution is

$$\bar{w}(r,s)_c = A\, I_o\left(\sqrt{\frac{s}{\alpha}}\, r\right) + B\, K_o\left(\sqrt{\frac{s}{\alpha}}\, r\right)$$

Equation (21)

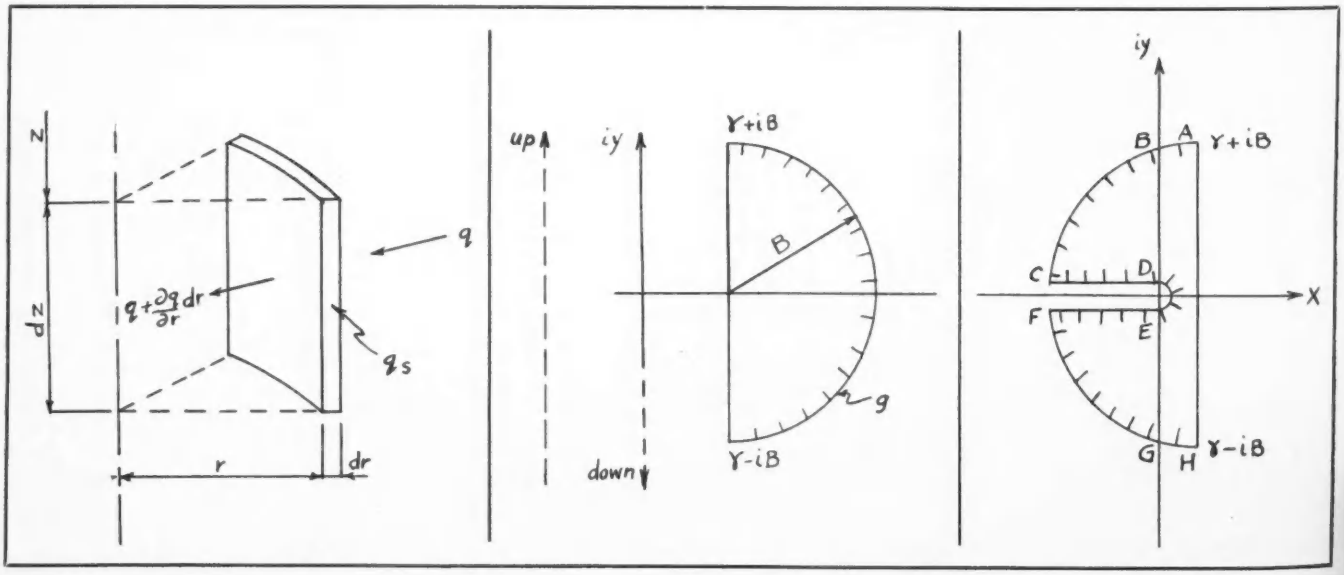

FIGURE 1 FIGURE 2 FIGURE 3

You can depend on PARKERSBURG PUMPERS For DEPENDABLE PERFORMANCE

Remote, hard-to reach locations are the acid test of pump performance. And that is where the industry-famous dependability of Parkersburg Pumping Units really pays off. Hour after hour, month in and month out they run smoothly on, never faltering in their lonely vigil of production. Experience has proved you can trust Parkersburg Pumpers for dependable performance.

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Sprocket shafts are supported by adjustable, self-aligning tapered roller bearings. Wrist pin bearings are also tapered roller bearings. Saddle and tailboard bearings are weather-proof, self-oiling type. Units can be equipped with electric motors or multi-cylinder engines. They are completely skid mounted for ease of installation and portability.

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where A and B are constants, $I_o\left(\sqrt{\frac{s}{\alpha}}\,r\right)$ is the modified Bessel function of the first kind and $K_o\left(\sqrt{\frac{\alpha}{s}}\,r\right)$ is the second solution; $K_o\left(\sqrt{\frac{s}{\alpha}}\,r\right)$ is called a modified Bessel function of the second kind; and $\bar{w}(r,s)_c$ is the solution to the homogeneous part of (19). The solution of the modified Bessel equation of zero order is well known (see Bowman,[8] p. 41). Thus

$$\bar{w}(r,s) = A\,I_o\left(\sqrt{\frac{s}{\alpha}}\,r\right) + B\,K_o\left(\sqrt{\frac{s}{\alpha}}\,r\right) + \frac{W(z)}{s} \qquad \text{Equation (22)}$$

The inverse transform of the last term in (22) is W(z). Therefore, of the foregoing, only $\bar{w}(r,s)_c$ remains. The condition on $\bar{w}(r,s)$ from (17) becomes

$$\bar{w}(a,s)_c = \frac{W(a) - W(z)}{s}$$

$$\bar{w}(\infty,s)_c = \frac{W(z)}{s} - \frac{W(z)}{s} = 0 \qquad \text{Equation (23)}$$

From (23), the constants of (22) are

$$A = 0$$

$$B = \frac{W(a) - W(z)}{s}\left[\frac{1}{K_o\left(\sqrt{\frac{s}{\alpha}}\,a\right)}\right]$$

Consequently the homogeneous part of (22) is given by

$$\bar{w}(r,s)_c = \frac{W(a) - W(z)}{s}\left[\frac{K_o\left(\sqrt{\frac{s}{\alpha}}\,r\right)}{K_o\left(\sqrt{\frac{s}{\alpha}}\,a\right)}\right] \qquad \text{Equation (24)}$$

Now, the asymptotic expansion of $K_o(x)$ is given by

$$K_o(x) = \left(\frac{\pi}{2x}\right)^{1/2} e^{-x}\left[1 - \frac{1}{8x} + \frac{1^2 \cdot 3^2}{2!}\frac{1}{8x^2} \cdots\right] \qquad \text{Equation (25)}$$

(see Bowman,[8] p. 84). Accordingly

$$\bar{w}(r,s)_c \cong \frac{W(a) - W(z)}{s}\left(\frac{a}{r}\right)^{1/2} e^{-\sqrt{\frac{s}{\alpha}}(r-a)}\left[\frac{1 - \frac{1}{8\sqrt{\frac{s}{\alpha}}\,r} \cdots}{1 - \frac{1}{8\sqrt{\frac{s}{\alpha}}\,a} \cdots}\right]$$

For r less than something large,

$$\bar{w}(r,s)_c \cong \frac{W(a) - W(z)}{s}\left(\frac{a}{r}\right)^{1/2} e^{-\sqrt{\frac{s}{\alpha}}(r-a)} \qquad \text{Equation (26)}$$

and $W(r,t)_c = L^{-1}\left[\bar{w}(r,s)_c\right]$

From (16) it immediately follows that

$$W(r,t)_c = \frac{1}{2\pi i}\int_{\gamma-iB}^{\gamma+iB} \frac{W(a) - W(z)}{\xi}\left(\frac{a}{r}\right)^{1/2} e^{-\sqrt{\frac{\xi}{\alpha}}(r-a) + \xi t}\, a\xi \qquad \text{Equation (27)}$$

Then W(r,t), the temperature function for the case of constant, and bounded, boundary conditions is

$$W(r,t) = W(r,t)_c + W(z) \qquad \text{Equation (28)}$$

where $W(r,t)_c$ is given by equation (27)

Now, it can be seen that the integrand of (27) is not defined at $\xi = 0$; furthermore, it is multi-valued at $\pm\pi$ and is otherwise analytic in the complex plane $s = x + iy$. Thus it is possible to evaluate (27) by a proper choice of path and line integration, for the integrand is analytic in G provided $\xi = \rho_v e^{i\phi}$ and $\xi = 0$ are excluded from G. Figure 3 is such a path. For the present, let (27) become

$$W(r,t)_c = \frac{1}{2\pi i}\left[W(a) - W(z)\right]\left(\frac{a}{r}\right)^{1/2}\int_{\gamma-iB}^{\gamma+iB} f(\phi)\,d\phi$$

From the Cauchy integral formula and Figure 3,

$$\frac{1}{2\pi i}\left[W(a) - W(z)\right]\left(\frac{a}{r}\right)^{1/2}\left[\int_{\gamma-iB}^{\gamma+iB} f(\phi)\,d\phi + \int_{P} f(\phi)\,d\phi\right] = 0$$

Thus

$$W(r,t)_c = -\frac{1}{2\pi i}\left[W(a) - W(z)\right]\left(\frac{a}{r}\right)^{1/2}\int_{P} f(\phi)\,d\phi \qquad \text{Equation (29)}$$

But with $B \to \infty$, (29) becomes

$$W(r,t)_c = -\frac{1}{2\pi i}\left[W(a) - W(z)\right]\left(\frac{a}{r}\right)^{1/2}\left[\int_{\text{P along CD}} \frac{f(\phi)\,d\phi}{} + \int_{\substack{\rho_v = e^{i\phi} \\ \rho_v \to 0}} f(\phi)\,d\phi + \int_{\text{P along EF}} \frac{f(\phi)\,d\phi}{}\right] \qquad \text{Equation (30)}$$

Let the substitution in (30) be such that

$$W(r,t)_c = -\frac{1}{2\pi i}\left[W(a) - W(z)\right]\left(\frac{a}{r}\right)^{1/2}\left[{}^{I}CD + {}^{I}\rho_v + {}^{I}EF\right] \qquad \text{Equation (31)}$$

Then

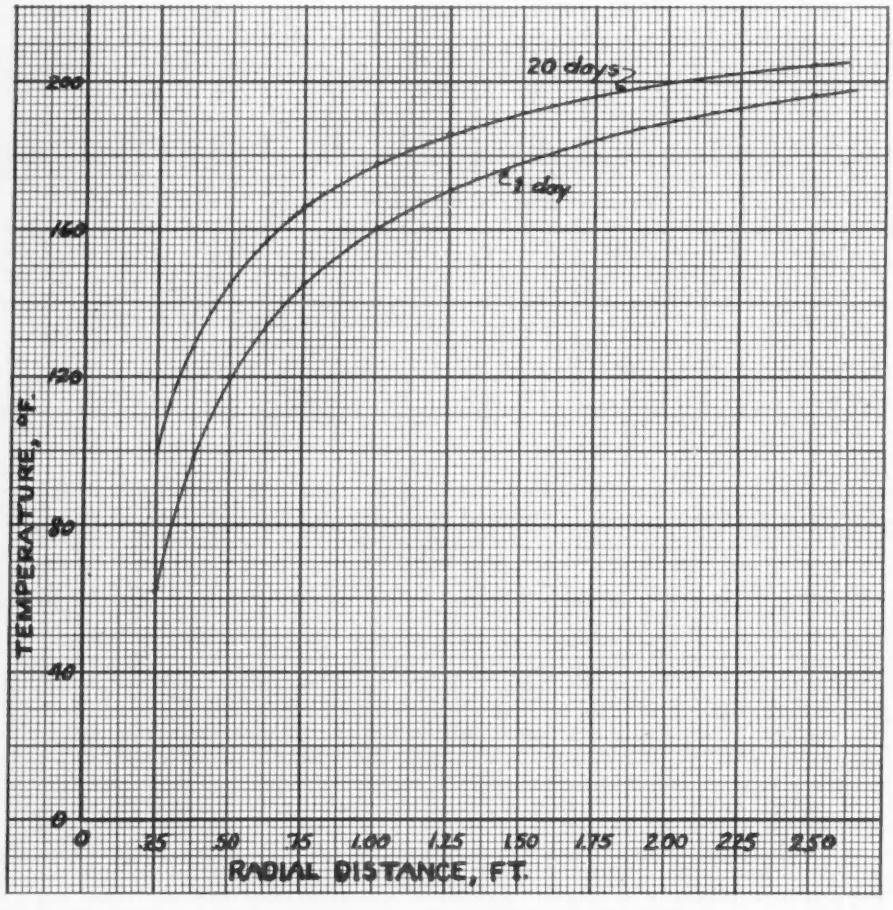

FIGURE 4. Temperature gradients along a radial line for:
a = 0.25 feet
W(a) — W(z) = —200° F.
m = 2° temperature rise per 24 hours = 0.0833
α = 0.032

It doesn't have to be this way...

"Sorry, Steve, but you gotta go back to the Peterson... rods parted in No. 11 just after you left. We'll have to get them fixed before we can pull the two Dunlap wells... If you see Shorty, tell him to high tail it to the C. Jones with his paraffin gang, 3 lead lines there are plugged solid... I'll try to locate a contract unit, but... etc., etc."

It can be like this!

"Bruth-h-er, if it wasn't for those Free Pumps, we'd be trying to find the roads this morning. All the pumpers have checked in... They don't have any problems they can't handle. So, why don't you have the gang work on tools in the garage, today?"

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There's nothing magic about *Free Pumping*—it just seems like there is. Producers accustomed to having operating costs go up when the weather gets rough are almost always amazed to find that when they install *Free Pumps*, bad weather doesn't affect the system's low operating costs.

The reason, of course, is that with *Free Pumps* installed, the lease pumper, without help, can handle all operating problems that arise. For example, if paraffin is plugging lines and tubing he can handle it easily with Kobe soluble plugs. If a well goes off he can readily change-out the bottom-hole *Free Pump*. Features such as these are responsible for the ability of *Free Pumps* to cut operating costs by 30% to 50%—regardless of the weather or operating conditions.

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$$I_F = \int_{\rho_v = 0} \frac{d\zeta}{\zeta} = -2\pi n i$$

Equation (32)

$$\zeta = \rho_v e^{i\theta}$$

$$I_{CD} + I_{EF} = \int_0^\infty e^{-\rho_v t} \frac{2i \sin \sqrt{\frac{\rho_v}{\alpha}} (r-a)\, d\rho_v}{\rho_v}$$

Equation (33)

After some rearrangement and substitution (33) becomes

$$4i \int_0^\infty e^{\frac{-\lambda^2 \alpha t}{(r-a)^2}} \frac{\sin \lambda}{\lambda} d\lambda$$

where

$$\lambda = \sqrt{\frac{\rho_v}{\alpha}} (r-a)$$

In Peirce,[11] the definite integral

$$\int_0^\infty e^{-c^2x^2} \cos bx\, dx = \frac{\sqrt{\pi}\, e^{\frac{-b^2}{4a^2}}}{2c}$$

is given, page 104. Integrating by db over the interval [0, b], it follows that

$$\int_0^\infty e^{-c^2x^2} \frac{\sin bx}{x} dx = \int_0^b \frac{\sqrt{\pi}\, e^{\frac{-b^2}{4c^2}}}{2c} db$$

Equation (34)

$$= \sqrt{\pi} \int_0^{b/2c} e^{-y^2} dy$$

where $y^2 = \frac{b^2}{4c^2}$.

Therefore

$$4i \int_0^\infty e^{\frac{-\lambda^2 \alpha t}{(r-a)^2}} \frac{\sin \lambda}{\lambda} d\lambda = 4i\sqrt{\pi} \int_0^{\frac{r-a}{2\sqrt{\alpha t}}} e^{-y^2} dy$$

$$= 4i\pi \operatorname{erf} \frac{(r-a)}{2\sqrt{\alpha t}}$$

The tabulation of erf (x) is given by Peirce,[11] page 116.

Hence, the bracket part of (13) is

$$-2\pi n + 4i\sqrt{\pi} \operatorname{erf} \frac{(r-a)}{2\sqrt{\alpha t}}$$

$$= -2\pi i \left[1 - \frac{2}{\sqrt{\pi}} \operatorname{erf} \frac{(r-a)}{2\sqrt{\alpha t}} \right]$$

$$= -2\pi i \operatorname{erfc} \frac{(r-a)}{2\sqrt{\alpha t}}$$

Equation (35)

From (31) and (35),

$$W(r,t)_c = [W(a) - W(z)] \left(\frac{a}{r}\right)^{1/2} \operatorname{erfc} \frac{(r-a)}{2\sqrt{\alpha t}}$$

and

$$W(r,t) = [W(a) - W(z)] \left(\frac{a}{r}\right)^{1/2} \operatorname{erfc} \frac{(r-a)}{2\sqrt{\alpha t}} + W(z)$$

Equation (36)

It is immediately clear that (36) reduces to W(a) at r = a, and to W(z) at $r \to \infty$, and to W(z) at $t \to \infty$.

Solution for the Conduction Equation with W(a, t) = F(t).

Let the temperature function be lowered by W(z), solved, then raised again. This operation simplifies the problem. That is, let

$$W(r\,0) = 0$$
$$W(a, t) = F(t) - W(z) = F_1(t)$$
$$W(\infty, t) = 0$$

Equations (37)

The transformed conduction equation is

$$\frac{d^2\bar{w}(r,s)}{dr^2} + \frac{1}{r}\frac{d\bar{w}(r,s)}{dr} - \frac{s\bar{w}(r,s)}{\alpha} = 0$$

Equation (38)

and the conditions on (38) are

$$\bar{w}(a, s) = f_1(s)$$
$$\bar{w}(\infty, s) = 0$$

Equations (39)

Now let a new function $\bar{z}(r, s)$ satisfy (38) and let the conditions be that

$$\bar{z}(a,s) = \frac{1}{s}$$
$$\bar{z}(\infty,s) = 0$$

Equation (40)

Multiplication of (40) by $sf_1(s)$ yields

$$sf_1(s)\, z(a,s) = f_1(s)$$
$$sf_1(s)\, \bar{z}(\infty,s) = 0$$

Equation (41)

But (41) is the same as (39). It follows, therefore, that $sf_1(s)\ \bar{z}(r,s) = \bar{w}(r,s)$

Equation (42)

Now put F(t) = W(a) + mt, that is, let the temperature W(a,t) be such that at t = 0, W(a,t) = W(a) and when t > 0, W(a,t) = W(a) + $\bar{w}$(t), where $\bar{w}$(t) is a linear function of t. Then

$$sf_1(s) = s\left[\frac{W(a)}{s} + \frac{m}{s^2} - \frac{W(s)}{s}\right]$$

$$\bar{z}(r,s) = \frac{1}{s}\left(\frac{a}{r}\right)^{1/2} e - \sqrt{\frac{s}{\alpha}}(r-a)$$

and hence

$$\bar{w}(r,s) = \left[W(a) - W(z) + \frac{m}{s}\right]\frac{1}{s}\left(\frac{a}{r}\right)^{1/2} e - \sqrt{\frac{s}{\alpha}}(r-a)$$

Equation (43)

or

$$W(z) = W(z)\Big|_{w(r,s)} =$$

$$\left[W(a) - W(z) + \frac{m}{s}\right]\frac{1}{s}\left(\frac{a}{r}\right)^{1/2} e - \sqrt{\frac{s}{\alpha}}\,(r-a) + \frac{W(z)}{s}$$

(Equation (44)

The inverse transform of (44) yields

$$W(r,t) = \left[W(a) - W(z)\right]\left(\frac{a}{r}\right)^{1/2} \operatorname{erfc} \frac{(r-a)}{2\sqrt{\alpha t}}$$

$$+ m\left(\frac{a}{r}\right)^{1/2}\left[t + \frac{(r-a)^2}{2\alpha} \operatorname{erfc} \frac{(r-a)}{2\sqrt{\alpha t}} - (r-a)\left(\frac{t}{\pi\alpha}\right)^{1/2} e - \frac{(r-a)^2}{4\alpha t}\right]$$

$$+ W(z)$$

Equation (45)

It is clear that (45) satisfies the initial and boundary conditions.

For the region close to the hole, where r is of the same order of magnitude as a, equations (36) and (45) after a very short time become

$$W(r,t) = \left[W(a) - W(z)\right]\left(\frac{a}{r}\right)^{1/2} + W(z)$$

Equation (46)

and

$$W(r,t) = \left[W(a) - W(z)\right]\left(\frac{a}{r}\right)^{1/2} + m\left(\frac{a}{r}\right)^{1/2}\left[t - (r-a)\left(\frac{t}{\pi\alpha}\right)^{1/2}\right] + W(z)$$

Equation (47)

respectively.

Equation (47) is tabulated in Table 1 and plotted in Figure 4 for the following set of conditions:

a = 0.25 feet
W(a) — W(z) = 200° F.
m = 2° F. temperature rise per 24 hrs.
t = 24, 120, 240, 360, and 480 hours
α = 0.032 (limestone formation[13])

These conditions correspond to a thermal gradient of 1° F. rise for every 50 feet of depth, a surface temperature of

TABLE 1
Temperatures, Degrees Fahrenheit

Distance From Center of Hole, Feet	TIME, HOURS				
	24	120	240	360	480
0.250	62.0	70.0	80.0	90.0	100.0
0.375	98.0	104.4	112.4	120.5	128.6
0.500	119.7	125.0	131.9	138.8	145.7
0.625	134.4	139.3	145.4	151.5	157.6
0.750	145.3	149.4	154.9	160.3	165.9
1.000	160.5	163.9	168.5	173.1	177.8
1.250	170.8	173.7	177.6	181.7	185.8
2.500	196.6	197.9	200.2	202.7	204.3

60° F., and z = 10,000 feet. The temperature of the drilling fluid at the bit is taken to be the same as at the mud pumps—that is, the temperature change of the fluid as it goes down is negligible. This assumption can be supported by supposing that the entire energy input to the drilling column is consumed in heating the corresponding volume of drilling fluid: the resulting rise in temperature of the fluid is perhaps 5 degrees. While the upward-flowing fluid also absorbs heat from the well walls, the heat conducted to the inside of the drill pipe is of zero order.

NOTATION

r, $\ominus$, z Cylindrical coordinates
a Radius of hole, ft.
b Outer radius of a thick-walled cylinder, ft.
q Heat flux in the radial direction, BTU/hr.
q_s Stored heat, BTU/hr.
t Time, hours
K Proportionality constant, thermal conductivity, BTU/hr. ft. °F.
W(r,t) Radial temperature distribution at a specified level, z, as a function of r and t, °F.
c Specific heat, BTU/lb. °F.
ρ Specific weight, lb./cu. ft.
α $K/c\rho$, diffusivity, ft.²/hr.
W(a,t) Boundary temperature at r = a, $t \geq 0$, °F.
$W(\infty,t)$ Boundary temperature at r = ∞, $t \geq 0$, °F.
W(r,0) Initial temperature, $t < 0$, °F.
G Analytic region

$\bar{w}(r,s)$ Laplace transform of W(r,t)
ξ The complex number, s, on a circle boundary
ρ_v Modulus of s on any boundary
z(r,t) Auxiliary function, °F.
m Temperature rise at a and at any z, °F./hr.
σ_r, σ_θ, σ_z, Radial, tangential, and vertical normal stresses, psi
ν Poisson's ratio
μ Coefficient of thermal expansion
ϵ_z Unit strain in the z direction, in./in.
E Modulus of elasticity, psi
T Temperature change, °F.
P_i Fluid pressure within the hole, psi

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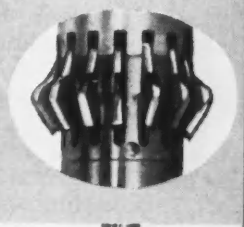

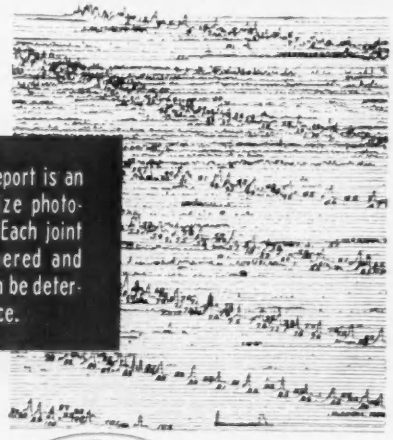

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Influence Of CLAY In Oil Production

By BEN B. COX

Gulf Research & Development Company, Pittsburgh

CLAYS, ALTHOUGH not in themselves sources of commercial production, frequently can influence the operation of a sand to such an extent that, if not provided for, loss of well or even failure to note possible zones may be involved. The author discusses the various means whereby clay may modify productive capacities, and also provides basic data for further investigations under producing conditions. This paper is from the Technical Program of a Production Engineering Conference of Gulf Oil Corporation held in Pittsburgh.

CLAY is a universal component of soils and sedimentary rocks. Shales, which make up about 80 percent of the total sediments, are composed chiefly of clays and silts. Until recently the geologist has confined his investigation of shales largely to the recording of the thickness, bedding, color, and faunal contents. The engineer has noted whether or not shales cause difficulty during drilling or in core analysis. Remedial efforts in drilling operations and in reservoir engineering of necessity have been largely empirical in the absence of adequate fundamental knowledge of clay minerals. Realization of this need has led several oil companies to undertake fundamental as well as applied research on clay minerals.

Universities and other public research groups are being encouraged to expand their fundamental clay studies. API Project 49, "Clay Mineral Standards," Paul F. Kerr, director, Columbia University, is one of these. Grim and Bradley of the Illinois Geological Survey; Marshall and Keller of the University of Missouri; Norton and Hauser of M.I.T.; Griffiths and Bates at The Pennsylvania State College; Ross and Faust of the U. S. Geological Survey; and the soils departments of several universities are among those currently engaged in fundamental clay studies. Foreign groups, notably in the agricultural experimental stations of Holland and Great Britain, are studying clay in its relationship to earth science problems. Since the war the Clay Minerals Group of the Mineralogical Society of Great Britain and Ireland has published several excellent abstracts bearing more or less directly on some of the oil industry's problems.

A few problems in oil production which are believed to be influenced by clay will be listed here. Depending on the kind of clay and the cations brought into contact with it, clay may be a binder of unconsolidated sediments, it may be a disrupting material, or it may be a plugging material in a sand. Dispersion and flocculation of clays are fairly well understood, but the mechanism of granulation is unknown.

Heaving Shale

Heaving shale of the swelling clay type has been reduced by using low-water-loss natural mud, oil-base mud, sodium silicate mud, or salt water-starch or lime-starch mud, but these remedial measures are not successful in all cases.

Producing sands are often classified by the operator as "clean sand" or "dirty sand." Sands, with few exceptions, include more or less clay and silt. The arrangement of the clay in a reservoir sand is important because the arrangement may profoundly affect completion practice, flow rate from the reservoir, and total economic recovery. The swelling of clay, or the rearrangement of clay in a sand during well completion, during production or during water flooding, may disrupt an uncemented sand at the drill hole face or tend to plug a cemented sand. Without adequate electric log interpretation, a very dirty sand or a fine-grained sand which is plugged by swelling clay, probably would be missed in a wildcat well. In a proven field, such a sand might not yield its oil on test and the horizon go recorded as "absent," as "a facies change to shale," or that the "sand would not produce." Production rates may be seriously reduced by swelling clay unless proper precautions and remedial measures can be undertaken or can be developed.

Production has been found in a few instances in fractured shale reservoirs. To improve production, the introduction of acid, which flocculates most clays and which may increase permeability under favorable conditions, has been tried. In at least one case, however, the introduction of acid not only shut off production but also caused sloughing and the loss of the hole.

Much very high grade empirical research has been done on drilling muds by numerous investigators, but increased knowledge of the chemical and physical properties of clays will make possible much better drilling muds than are available today. Good gel-forming characteristics are believed to be limited chiefly to certain types of the montmorillonites. The thixotropic properties are closely re-

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lated to the captured base, and the gelling time can be regulated within certain limits by changing the kinds and amounts of dissolved cations in the mud. Saturation with Na^+-ions using a sodium salt giving an alkaline reaction is a common practice to increase gel strength. The explanation of this sol-gel transformation is unknown, but it seems to be related to particle size and the type of particle as well as to the nature of the fluid medium.

The dispersion of clay is related to the cation on the clay and to the concentration and kind of cation in the wetting fluid. Although generalities may be misleading, most clays acquire their highly dispersed condition in dilute alkaline solutions, such as sodium carbonate, sodium bicarbonate, ammonium carbonate, or sodium hydroxide, and some sodium or potassium solutions having large negative radicals such as sodium acid pyrophosphate, sodium polyphosphate and sodium tannate. Very recently an exception has been reported. Hydrogen cations in an acid solution cause one type of hydrous mica to disperse and swell approximately as much as sodium montmorillonite swells in water. Since this is contrary to the assumption usually made in empirical studies, it is hoped that this clay mineral has been very rare in oil field sections.

Much study and experiment have gone into methods and equipment for coring uncemented sands. The driller usually calls them "loose sands," but under compaction beneath several thousand feet of overburden they are undoubtedly not loose. They are friable and may need to be supported mechanically in a well, during drilling or after completion, by a liner, a gravel pack, or properly cemented casing. It is suspected that the apparent looseness of the sand is manmade during drilling and that part of the difficulty in core recovery in "loose sands" is due primarily to base exchange caused by cations in the drilling fluid. Drilling fluid penetrates porous formations ahead of the bit at ordinary pump pressures. The process of base exchange takes place very rapidly, so that uncemented dirty sands, which include swelling type clays, can be under disruptive pressure as a result of base exchange before the core barrel cuts the core.

Arrangement of Clay

The arrangement of clay in a reservoir sand is of importance both to well completion and to recovery. During geologic time clays in any reservoir come to equilibrium with the interstitial water in the formations. The clay may occur as discrete particles in capillaries, as clay pebbles or clay sand grains which are commonly weathering products from feldspar or ferro-magnesian pebbles or feldspar or ferro-magnesian sand grains, or they may completely coat the sand grains. The introduction of water with different cations or concentrations of cations not in equilibrium with the cations on the formation clay will cause base exchange, and change the clay volume and the arrangement of the clay. Edge-waters more dilute than original interstitial water if allowed to interfinger into an oil sand, different type waters migrating through leaking cement jobs behind casing, or poorly chosen drilling fluid may cause great damage to wells and to reservoir permeability in uncemented sands. In a cemented fine-grained sand, the swelling of a small percentage of clay can completely plug the reservoir near the borehole. In such cases it is difficult or impossible to bring in the well.

In an uncemented rock, clay can act as a binder to hold the rock together, but if waters coming into contact with that clay are more dilute than the interstitial water, or if there are cations present which can exchange with the cations on the clay, shrinkage or swelling and consequent disruption may result. This may cause the well to sand up or it may cause plugging of perforations. A common remedial technique is pressure washing with oil. Continued cleanouts which produce large amounts of sand can be expected to lead to caving and other difficulties and the possible loss of the hole.

The introduction of many mud treating chemicals, as well as washing solutions many of which are active dispersers of clay, may promote disruption of an unconsolidated sand. On the other hand, such solutions may prove to be helpful in cemented sands having good initial permeability, if the casing has been cemented by the scratcher-centralizer technique. Otherwise the risk is run that such solutions may plug the well or remove mud from behind casing and bring other oil or water horizons into communication with the perforated interval.

Core analysts have recognized the errors which may be introduced into standard core analyses by the swelling, shrinking or rearrangement of clay during analysis. Pore water and adsorbed water in the clays of dirty sands are additive to effective interstitial water measured by the standard type core analysis. Shrinkage of clay during analysis alters effective porosity. Many organic liquids used in the extraction of cores enter the crystal lattice of a clay in a manner similar to water, but the volumetric result varies. The core analyst's procedures and methods must take these factors into account. He should know the kinds of clay in his cores and their physical properties.

Until recently, the importance of shale in the quantitative interpretation of the electric log was not recognized. It has been demonstrated[1] that the Nernst equation is applicable to the quantitative interpretation of the electric log. Salinities and percentage of connate water in rocks having intergranular porosity can be calculated. Some reservoir rocks have intrinsic conductivity which is due in part to the clay content.[2] In some cases this factor is large enough to require correction in the quantitative interpretation of an electric log.

During the compaction of sedi-

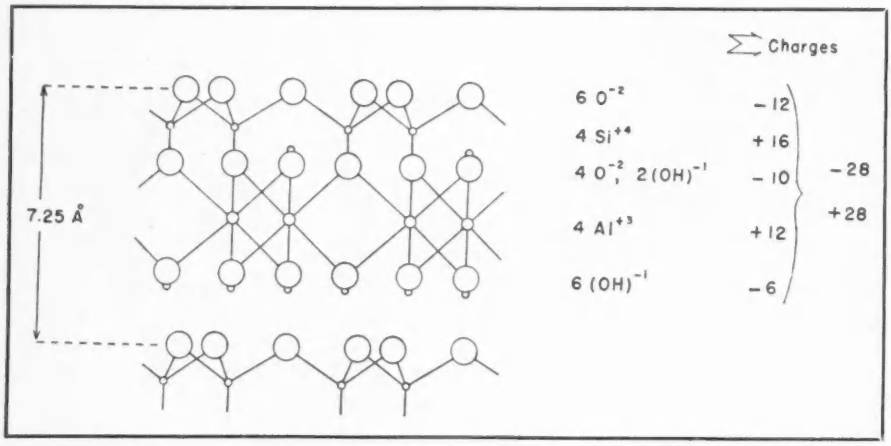

FIGURE 1. Unit cell of kaolinite. A single crystal may be composed of 1000 or so unit cells.

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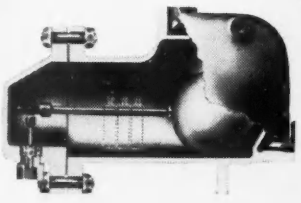

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ments under loading or compression, fluids are squeezed from the fine-grained materials, such as clay, silt or lime mud, into the competent porous rocks, such as sand and crystallized limestone. Shale or lime mud, therefore, is important not only in the origin and migration of petroleum but also as a convenient "mash" from which a water and pertoleum "brew" can be pressed.[3,4] Subsidence of the surface over oil fields has been credited to rearrangement of random-packed sand grains in thick sand sections as a result of decrease in reservoir pressure in the sand,[5] but more frequently such subsidence is probably due to increased compaction of shales by water loss to sand as reservoir pressure decreases. Until a shale is recrystallized or cemented, there is a delicate balance between the compaction pressure on a shale and the pressure in the sand reservoir. Reduction of a fraction of a pound in the hydrostatic pressure on the sand or the increase of a fraction of a pound on the shale will cause fluids to move from the shale to the sand. Because of the small size of clay particles, clays can be compressed to very small volumes by removal of pore water. Drying cracks in mud flats are a surface expression of this phenomenon. At Pierce Junction, subsidence occurred in an area unrelated to an oil field.[6] The cause was directly traceable to the compaction of a "gumbo" between two aquifers when water was removed from the lower aquifer.

The property of greater compressibility of shales as pressures are increased locally in a drill hole is suspected to be the principal cause of breakdown pressures in cement jobs and is probably the fundamental principle which makes possible the Hydrafrac process at pressures less than overburden pressure.

Clay is one of the most abundant substances on earth, about which we know less than any other type of rock. This has been due to the extremely small size of clay particles which are inherently small probably because of their structure and labile properties. Most clay mineral crystals are less than two microns (0.00008-inch) in diameter. The types which cause most trouble are less than 0.000008-inch in diameter. Until recently, adequate tools for their study had not been developed, but the Gulf Research & Development Company has acquired this equipment and has highly trained, specialized scientists who are qualified to make such studies.

Composition and Properties of Clays

No attempt is made here to touch on more than some of the high points of the mineralogy and physical chemistry of clay minerals. Clay minerals are essentially hydrated silicates of aluminum or more rarely hydrated magnesium silicates. The major clay mineral groups are the hydrous micas (illite), the kaolinite group, and the montmorillonite group. Of lesser importance are attapulgite and a few other substances.

Of these clay minerals, the structure of kaolinite is best established (Figure 1). It is composed of a tetrahedral layer of silicon and oxygen atoms and a superimposed octahedral layer in which the aluminum has six-fold coordination. It will be seen from Figure 1 that the negative and positive charges in a unit cell of kaolinite exactly balance. Except for discontinuity at crystal boundaries, pure kaolinite, therefore, does not exhibit base exchange properties. It will absorb some water, but is believed to cause comparatively little or no trouble in petroleum operations.

Montmorillonite (Figure 2) has a basal sheet of silicon-oxygen tetrahedra with a superimposed layer of aluminum atoms in octahedral coordination like kaolinite, but it has an

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additional sheet of silicon-oxygen tetrahedra bonded to the other side of the octahedral layer. It may be considered as a sandwich of an octahedral layer between two tetrahedral layers. The positive and negative charges on this unit cell are not balanced, except by loosely held cations shared by adjacent unit cells not shown. One Na^+ cation is illustrated, but the cation may be Li^+, Na^+, H^+, K^+, Rb^+, Cs^+, Mg^{++}, Ca^{++}, Sr^{++}, or Ba^{++}. but the cation may be Li^+, Na^+, H^+, K^+, Rb^+, Cs^+, Mg^{++}, Sr^{++}, or Ba^{++}. In naturally occurring montmorillonites, Na^+ and Ca^{++} appear to be the most common cations. The order of preference by this mineral for different cations from solutions of equivalent concentration is approximately in the order named above.[7] Exchange of one cation for another does not significantly change the fundamental nature of the clay crystal, but it may cause expansion of the lattice and great absorption of water. In general, Li^+ and Na^+ favor great swelling; H^+, K^+, Ca^{++}, Mg^{++}, Al^{++}, Fe^{++} considerably less so.

Aluminum may proxy for silicon in the tetrahedral layer in the montmorillonite group, and magnesium or iron can substitute for aluminum in octahedral coordination. This gives rise to the different members of this mineral group.

Hendricks has suggested that the layers of montmorillonite, if stacked one upon the other with slight translation or rotation between the sheets, might explain some of the variations in the predicted physical properties of this group, but the variation might be due to other causes.

The kind of replaceable bases on the clay profoundly affects the swelling characteristics of montmorillonite-type clays.

Hydrous micas, which have also been called illite, or potash-bearing bentonites,[8] are very common clays in sedimentary rocks. The structure and the origin of these minerals are not well known, but it is believed by some workers that the potassium is firmly held to the three-layer sheets of an illite-type structure and results in a more stable substance than montmorillonite.

Base exchange capacity—the ability of clay minerals to absorb and release cations — was discovered in 1850.[9] For the purposes of this paper, it is a reaction between a solid and a solution, usually a salt solution. Base exchange is not limited to clays, but we shall limit our remarks to clays.

According to W. P. Kelley, "Neither the anions of the solution nor the

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electronegative components of the solid are involved in base exchange *per se*. The solid undergoes no chemical change except the replacement of one cation by another. Other reactions may take place concurrently, but these are not part of base exchange. The adsorbed bases of clays are held to the solid by electrostatic attraction. The attraction is largely by coulomb forces in contrast to van der Waal forces. Adsorbed cations can be removed only by exchange for an equivalent of some other cation. Base exchange is stoichiometric and in general the process is completely reversible.

"Two conditions must exist before base exchange can take place to any great extent. First, the base must be on the external surface of the solid particles or on an internal surface such as intercommunicating channels or surfaces resulting from lattice expansion; the cation of the solid must be accessible to the solution. Second, the strength of attraction between the solid and the adsorbed base must not be too great, and this is the case with clays. In general, undissociated bases held by covalent bonds are not readily replaced by the base of a solution.

"Therefore, accessibility and strength of attraction are the two important conditions for base exchange."[9]

The relative activity of a given cation and its concentration in a solution have a direct bearing on the base exchange possibility of that cation. Simple dilution of formation water with distilled water will cause a limited amount of base exchange and this may cause some change in the physical properties of clay. Reduction in the concentration of formation water probably causes dispersion, swelling and disruption of the rock. Li^+ or Na^+ cations in an alkaline solution are even more effective.

The base exchange capacity of clay varies. In montmorillonites it ranges from approximately 60 to 100 milliequivalents per 100 grams, in the kaolinite group from 3 to 15, in hydrous micas (illite) from 20 to 40, and in attapulgite from 25 to 30.[10]

To study the effect of clays in formations penetrated by wells and to plan any remedial or preventative measures for problems believed to be caused by clays it is necessary to know what kinds of clay are in the formation, what the base exchange capacity is, and what cations are in the exchange position, and the concentration and kinds of cations in the solutions that may come into contact with the formation.

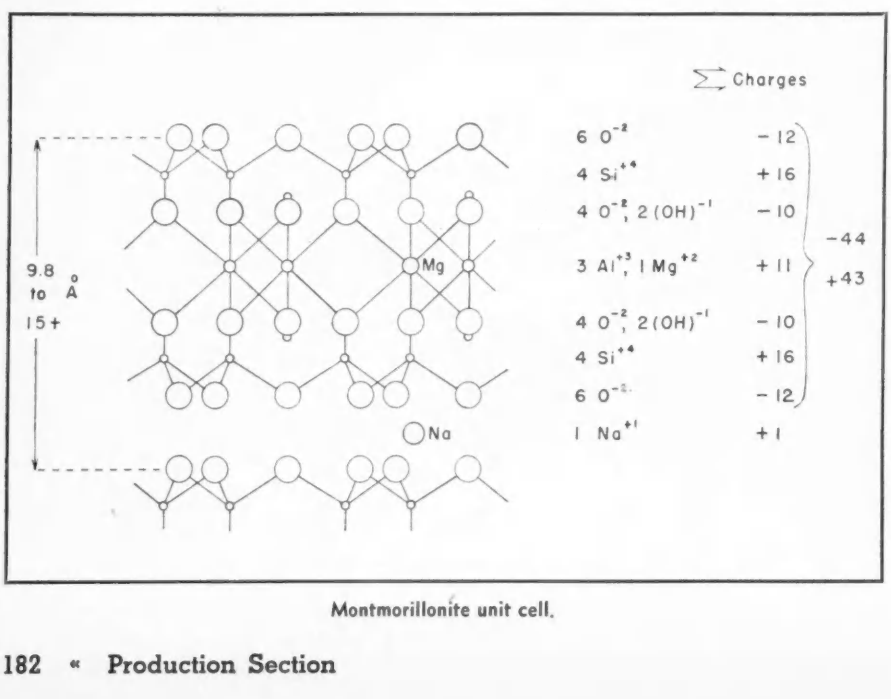
The absorption of water, the dispersion, the swelling, the granulation or the flocculation are directly related to the cation on expanding lattice-type clays. Polar organic substances, such as some compounds in petroleum, many of the alcohols and amines, will also enter the crystal lattice in much the same manner as water.

Pressures which arise as a consequence of the swelling process are appreciable, and although there may be only a small amount of clay present and only a part of that the expanding lattice-type, the pressure may be sufficient to disrupt a partially cemented or uncemented rock in a drill hole or a core barrel.

In field operations, therefore, it is important to know what kinds of clays are in friable formations where core recovery is poor, where sloughing or heaving occurs, and where sands having low connate water content fail to produce.

About the Author

BEN B. COX was born in Greenville, Ohio, and graduated with a B.S. degree in geology from the University of Chicago in 1921, obtaining his M.S. a year later. After serving as instructor in geology at the University of Iowa from 1922-25 he joined the Palmer Corporation as petroleum geologist and in 1927 became chief subsurface geologist for Iraq Petroleum Company, Ltd. In 1928 he joined the Near East Development Corporation and in 1935 transferred to Socony-Vacuum Oil Company, Inc., where he remained until he joined the Gulf Research and Development Company. He is a member of numerous scientific societies.



Montmorillonite unit cell.

ACKNOWLEDGMENTS

The writer is indebted to W. P. Kelley and Duncan McConnell for their advice and assistance in the preparation of this paper; to M. R. J. Wyllie, H. W. Patnode and A. J. Teplitz for criticism of the manuscript; and to Dr. Paul D. Foote, Executive Vice President of Gulf Research & Development Company for permission to publish.

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How to do it!

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HOW TO—Drain Firewall Enclosure

The space inside the firewalls of tank batteries in low, flat leases, is difficult to drain in the rainy seasons. One operator uses a jet in much the same manner as steam jets are used on drilling rigs to transfer mud. Instead of steam, natural gas is used for power. A connection is made on the gas line where it is used to agitate oil emulsions, and a swing joint is installed so that the line will reach to the lowest point inside the dikes.

On the outer end of the 1-inch gas line, a nipple is installed looking down and a return line is swaged down to ¼-inch to form the jet. The jet line is a short joint of 2-inch pipe bent to lay over the top of the dike. In operation, it is placed with the intake end in the bottom of the pond and with the gas jet thrust inside. The gas pressure is then turned on and the gas forces out a stream of water.

Being portable, the device can be used on several batteries where it is impossible to install bleed lines on the tank dikes, due to the flatness of the country.

HOW TO—Identify Buried Valves

Opening or closing the wrong valve at the tank battery can cause serious trouble in overflowing a tank or shutting in production from several wells. To avoid such accidents by mistaken identity of valves buried below ground level at a tank battery receiving oil from about 20 wells, one company makes it a practice of positively identifying these valves with standard name tags as illustrated.

Because one pumper may be required to take care of several such batteries, and also to help new men on the job and identify these valves in the dark, this valve identification system was set up to prevent opening or closing the wrong valve. The valves shown are of the rising stem type. The identifying tag for each is placed just behind it with the full name of the valve printed on the metal piece. Metal rods are threaded on one end and driven into the ground behind the valve. The identifying tag was cut from sheet metal with a strip about 1½ inches wide extending below it. The lower two inches is bent at right angles and drilled to fit over the threaded end of the vertical rod. The sign is then placed between two nuts screwed onto the rod and the nuts are tightened to hold the tag securely in place. On valves where the stems do not rise and the valve wheel is bolted to the valve stem, the identifying signs are placed under the valve stem nut and turn as the valve wheel is rotated.

HOW TO—Attach Guard to Well Pumping Jack

Wells pumped from a central power unit connected to pumping jacks create no noise to keep roaming cattle from beneath the outer end of the walking beam. One company uses short pieces of salvaged sucker rod material to fashion guards for the jacks.

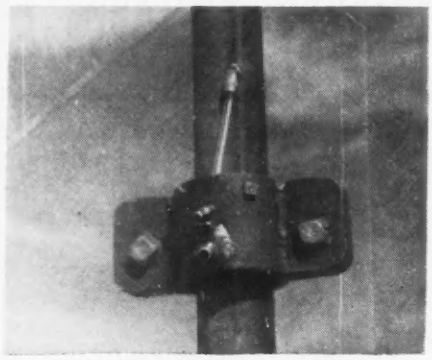
Using two pieces of rod material approximately ten feet long, the ends are welded flat to the back end of the walking beam with the rods pointing downward. The guards are then bent in a semi-circle and welded to the saddle on the lower end of the jack. Two pieces of rod are then welded between the runners to effectively brace the guards.

Before calling the job complete, the guard is painted the color of the jack. The outer end of the beam is painted a bright orange and two strips of orange are painted on the guard itself. With this arrangement, it was found that there was no danger of stock or workmen or children being struck by the moving beam.

HOW TO—

Measure Heat of Flowing Gas Line

On a line where there is no thermometer well, a simple device may be fabricated to give readings approximate to those obtained in a thermometer well. A clamp fits around the pipe and is held in position by two bolts, one through either side. The well for the thermometer is made by cutting a section out of a piece of old rubber



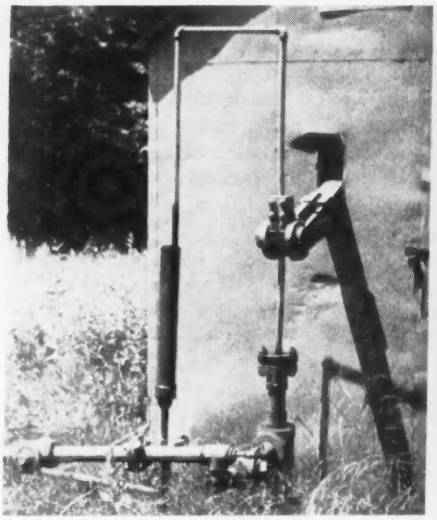
tube and fastening it inside the clamp with two stove bolts. At the bottom of the well, a drain cock is brazed in place.

When it is desired to get the well head or flowing temperature of a gas stream, the clamp is bolted on the line with the rubber against the line. Mercury is then poured into the opening between the clamp and the line, and the thermometer inserted into the mercury chamber.

To move the clamp, the mercury is drained from the chamber and kept in a bottle until ready for use again.

HOW TO—

Connect Well-Head To Pump Gas Well



Old gas wells must be kept free of water in order to maintain enough pressure to feed gas into the system. If the tubing is set on a packer and the annulus if full of water, the water must be raised through the tubing.

One gas company uses three-fourths-inch pipe for sucker rods and pumps the water out through the hollow rods. The pump is set below perforations in the tubing so that any gas coming into the well bore comes up on the outside of the rods and the liquid is pumped out through the rods.

A simple connection for carrying the water to the salt water pit is illustrated. The three-fourths-inch pipe used for rods is clamped to the beam and then is turned back down inside a two-inch riser which leads to the salt water pit. As the well is pumped, the smaller pipe rides up and down inside the larger pipe and empties its contents. A valve at the bottom of the two-inch riser can be closed to determine whether the well is pumping and the nature of the liquid being pumped.

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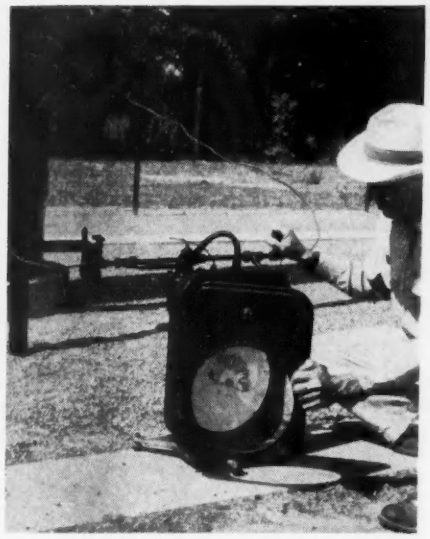
ning into one of the moving parts. The moving spots of color also enable the pumper to quickly determine from a distance which wells, particularly those pumping with a very slow motion, are in operation at a particular time. On leases covered with the 5 or 6-foot high brush commonly found in some areas, possibly only the uppermost part of the pumping unit can be seen from a distance and the ability to see the moving bits of color can help reduce the amount of driving ordinarily required to check up on individual wells.

HOW TO—
Connect Portable Meter to Gas Riser



To test wells periodically for gas-oil ratios and potentials, a simple, portable meter may be arranged as shown. The support is made from a two-inch nipple and is mounted on a tripod for easy leveling at each new station. Because the orifice flanges are installed on the gas riser on the separator, they are always above the meter, so the piping is built on the top of the meter with the high and low pressure connections leading out horizontally.

In effect, the meter is set on the line leading between the two connections on the orifice flange, with a needle valve set between them. The meter is leveled and zeroed, then the copper tubing is connected to either side and it is ready for use. The valve on the piping can be opened if it is necessary to equalize the pressures on each side of the meter.

A carrying strap was made by loosening the connection on the static pressure line and one of the bolts on top of the case and slipping loops from a strap over them and tightening them back down.

Photo courtesy: Cliff Hyde Flying Service, Houston

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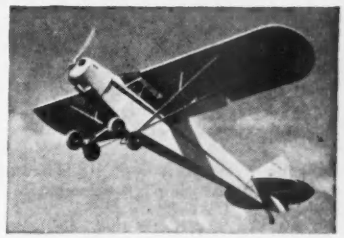

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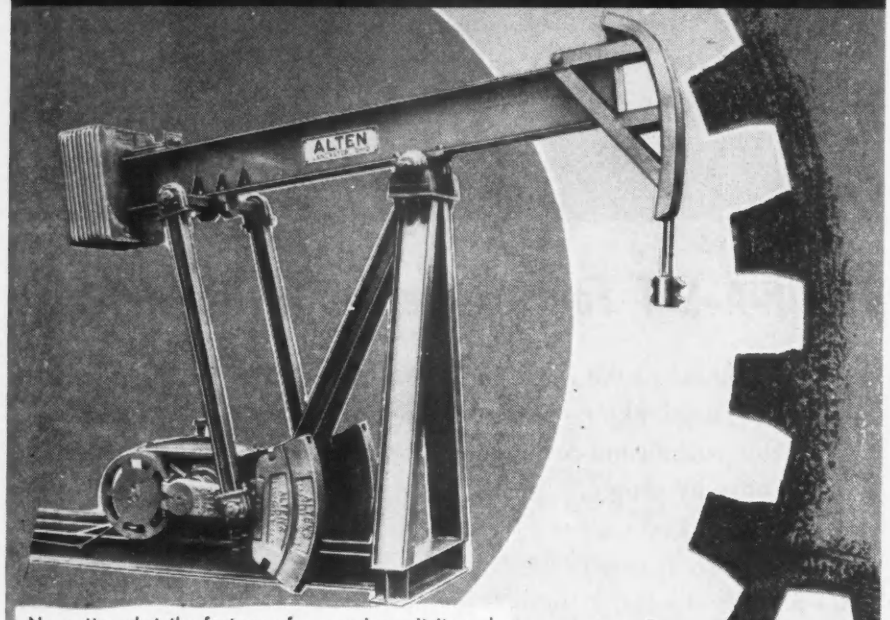

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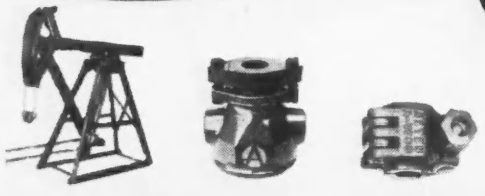

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HOW TO—
Fabricate Improved Oil Well Enclosure

An improved fastening which allows the removable sections of a well enclosure to be tightened securely without brackets or latching devices is being used with considerable success. The enclosure is made of parallel bars of two-inch pipe connected at corner posts made of the same material. The design is simple, yet effective, and prevents livestock from approaching too close to well head fittings and equipment. Only eight bolts are required to hold the enclosure together, four on each of two opposite panels. As can be seen by close inspection of the corner post in the foreground, one pair of panels is welded up to make complete units, with the two horizontal bars being welded to the corner posts.

The other panels consist of pipe bars which attach individually to these corner posts. At each end of an individual bar is welded a short half-section of pipe ap-

proximately 3 inches long. In the center of this half-section is welded a bolt, the latter being run through from the back side and welded in place before the piece of metal is welded to the concave-cut end of the pipe rail. Properly spaced holes then are burned through the corner posts, the axes of these holes being parallel to those of the individual bars. In assembling the enclosure, the individual rails are connected to the two complete sections by inserting the bolt-ends in their respective holes in the corner posts and tightening down with nuts.

One advantage of this type of enclosure, other than that the unit is simple and easy to install, is the ease with which it can be tightened up and made into a rigid, complete structure merely by cinching down on eight nuts.

HOW TO—Pump Lease Water Supply

When the first well is drilled on any lease, a water well is usually drilled nearby to furnish water for drilling and lease operations. One company makes it a practice to drill the well approximately eight feet from the oil well so that they can both be pumped from the same unit without a rod line.

As soon as the oil well is placed on the pump, the water well is tubed in the usual manner and the polish rod positioned to reach approximately six feet above ground. A 12-foot piece of two-inch pipe is then fastened to the top of the walking beam with U-bolts so that it hangs out over the water well. A turnbuckle with a hook on one end and an eye in the other is then fashioned with a loop of ¾-inch wire through the eye.

With the rods from the water well held on a polish rod clamp, the loop is slipped over the end of the two-inch piece and the clamp loosened. The well is now ready to pump.

When it is desired to unhook the well, the polish rod clamp is replaced and the loop removed from the two-inch piece on top of the beam.

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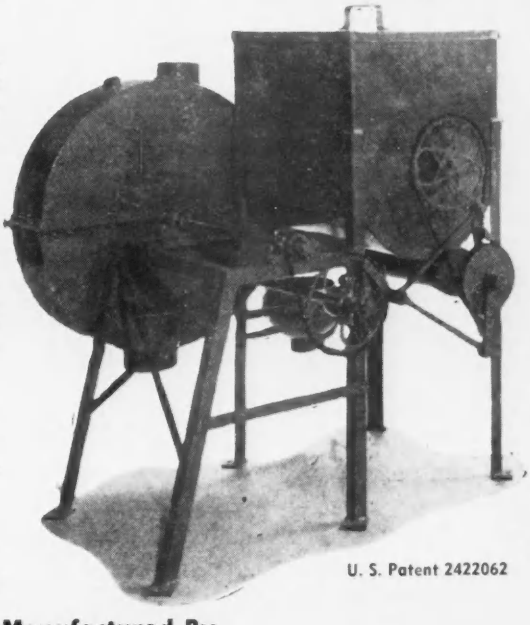

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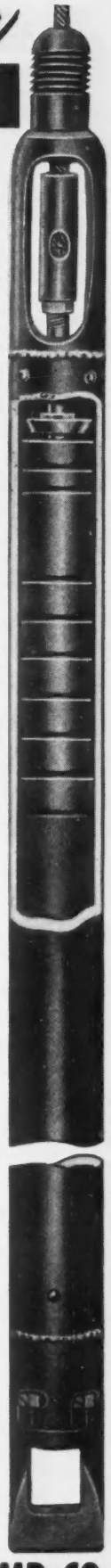

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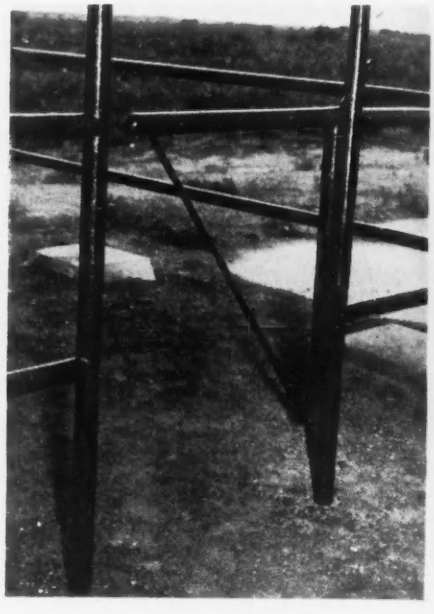
HOW TO—Make Self-Closing Gate



An improved well enclosure gate, one which is simple to construct and which requires no springs or counterweights to keep it closed when not in use, is shown. The gate is triangular and consists of two pieces of two-inch pipe welded together at right angles and connected across the two ends with a length of ¾-inch sucker rod.

The hinge or pivot point for the gate consists of a ¾-inch bolt run through a one-inch pipe nipple welded into place at a 45-degree angle in the gate post. The head of the bolt remains inside the two-inch pipe at the juncture of the two arms. The nipple, eight inches long, projects an inch or so on either side of the gate post, allowing sufficient clearance on the gate side for the gate to swing freely and providing a place on the other side for the ¾-inch nut to seat when the bolt is being tightened up or adjusted.

When the gate is opened, the weight of the vertical member, being pulled off vertical and acting as a pendulum, serves to bring the gate down to the closed position when it is released. The top bar tilts downward as the gate is pushed open, but ample room is allowed for a man to walk through the enclosure.

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(Patent Pending)

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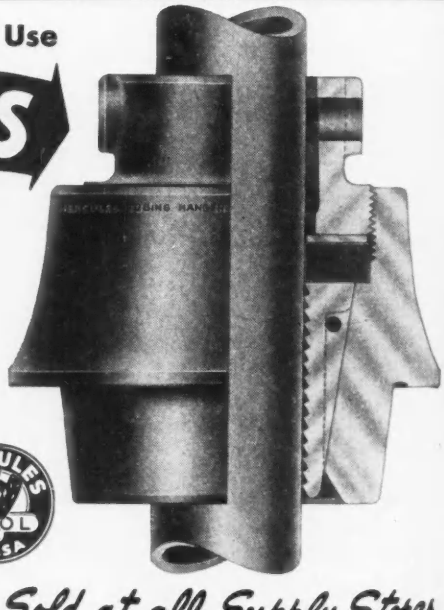

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(H. Pollard Photo)

Panoramic view of line being laid in Eastern Alberta.

Canada's "Big-Inch" Now Operating

By ANTHONY GIBBON
Mid-Continent District Editor

CRUDE oil from the prolific fields of Western Canada is now moving across half a continent through Interprovincial Pipe Line Company's 1127-mile Alberta-to-Great Lakes system and being stored at Superior, Wis. When the spring thaws make Lake Superior navigable the oil will resume its journey by tanker to supply the oil-hungry markets of Eastern Canada.

Completion of this major pipe line marks a milestone in Canadian economy. The pipe line is going into service at a critical time in the development of the Alberta oil industry. Successful exploration and the extremely rapid development drilling which followed the Leduc discovery in 1947 have built Western Canadian proven reserves to an amount in excess of 1 billion barrels. To make this vast new source of crude more widely accessible, additional transportation was needed. Without a pipe line, transportation costs are economically prohibitive, limiting the marketing of Alberta crude to the prairie region, while Canadians far from the source of supply seek requirements elsewhere.

As a Canadian business venture, it is expected to stop a drain on that country's economy of at least $150 million (U. S.) a year which heretofore has been spent for foreign crude. In time of war, it will diminish Canada's problem of obtaining imports of petroleum.

The pipe line represents an investment of about $90 million. When in full operation next spring it will move 95,000 barrels of crude out of Edmonton daily. About 70,000 barrels daily will continue eastward beyond Regina and deliveries to Superior will be about 55,000 barrels per day by next spring.

About 178,000 tons of high-test steel went into the pipe line.

A work schedule of 150 days was set for construction of the line and contractors on the two Canadian divisions bettered the time limit by more than a week. Completing the Interprovincial pipe line within that time makes it the fastest major undertaking of its kind. This was accomplished despite a national railway strike, floods in Manitoba, and difficult spring weather conditions. Approximately 1500 men were employed on construction during peak activity on the line. In order to meet the program, contracts went to firms with long experience in pipe line construction, with trained personnel and specialized machinery not available in Canada. These experts from the U. S. held key positions on the job but 80 percent of the men who built the line were Canadians.

THE INTERPROVINCIAL Pipe Line from central Alberta to the Great Lakes will cut the transport cost for oil down to between 23 and 24 cents a barrel. The cost to ship this oil the same distance by rail would approximate $2.43 a barrel.

A major pipe line to transport crude from Western Canada was considered as early as 1938 but it was not until discovery of the Leduc field that sufficient reserves were in sight to make the venture economically sound. Officials of Imperial Oil Limited initiated the first moves toward the realization of the pipe line, but that company was not then and is not now interested in getting into the pipe line business as such. But as one of the major producers in the new fields, Imperial has a big stake in this outlet to market. Imperial therefore promoted the organization of Interprovincial but retained only a one-third ownership in the new company. Other oil companies and private interests hold 25 percent, and 42 percent is in the hands of the public. Lakehead Pipe Line Company, Inc., a wholly-

owned subsidiary of Interprovincial, will own and operate the section of the line in the U. S.

Planning of the line was divided into two stages as a result of changes and developments in the Western Canadian producing picture. The pipe line as originally projected was to carry crude from the Edmonton area to refineries at Regina with any demands east of there to be supplied by rail from Regina. Discovery of the Redwater pool in the fall of 1948 indicated another major oil strike providing additional reserves to make a pipe line east of Regina economically sound.

During the first planning stage when the line was projected only to Regina engineers made pressure drop calculations for pipe of 16-, 18-, 20- and 22-inch O.D. with ¼-, 9/32-, 5/16- and 11/32-inch wall thickness, and as a result of these studies it was decided to use 16-inch pipe with three wall thicknesses — 5/16-, 9/32- and ¼-inch.

Following the Redwater development the pipe line planners went into the second stage and a new set of studies proved that Superior, Wis., was the logical treminus. It was decided to increase the size of the pipe in the Edmonton to Regina section from 16 to 20 inches O.D. and the 16-inch pipe was diverted from the Edmonton to Regina section, to the Regina to Gretna, Manitoba, section. Eighteen-inch diameter pipe was chosen for the American section of the line between the International boundary south of Gretna to Superior.

The completed line comprises three sections—439 miles of 20-inch, of which 82 miles has a wall thickness of 11/32 inch and the remainder 5/16 inch from Edmonton to Regina with an intermediate pumping station at Kerrobert, Saskatchewan; 336 miles of 16-inch, with 5/16-inch wall thickness from Regina to Gretna, with an intermediate station at Cromer; 320 miles of 18-inch, with 9/42-inch wall thickness from the Gretna station to a station at Clearwater, Minn., and on to Superior, and 30 miles of 16 inch between the Redwater field and Edmonton.

Hon. E. C. Manning, premier of Alberta (foreground) opens the valve which sent the first Alberta crude on its way eastward by pipe line. With him at the valve is Loren F. Kahle, executive vice president of Interprovincial Pipe Line Company, on loan to that company from Interstate Pipe Line Company, Tulsa, of which he is president.

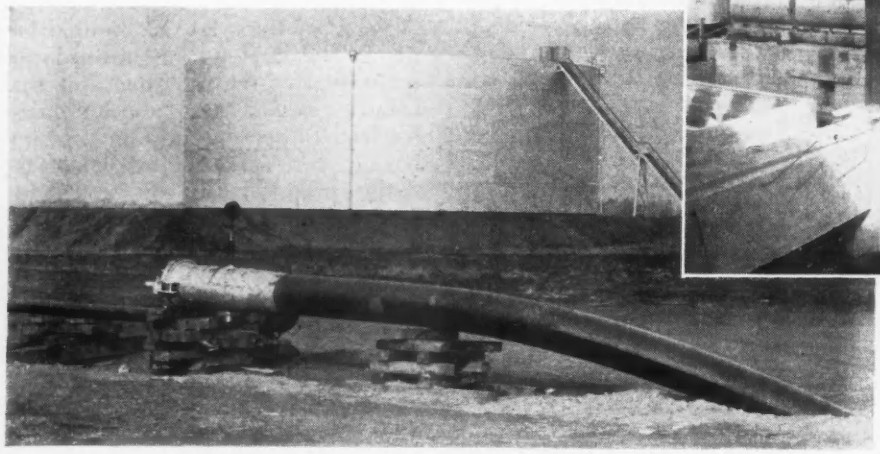
Obtaining the steel for this major pipe line resulted in interesting examples of cooperation among steel manufacturers in different countries. British manufacturers agreed to ship 30,000 to 40,000 tons of plate to Canada. This steel was not suitable for pipe rolling but satisfactory for other purposes. In exchange for this plate, The Steel Company of Canada agreed to release from its Hamilton plant enough special pipe line steel plate to permit Page-Hersey Tubes, Ltd., to produce a large portion of the required steel pipe. In order to meet this commitment, Page-Hersey constructed a completely new rolling mill at Welland, Ontario, at a cost of $5 million. Customers who would otherwise have used that special plate agreed to the slight inconvenience and were protected against any increased cost by the pipe line company.

The pipe line was divided into three divisions for construction. The 439-mile section from Edmonton to Regina was built by Bechtel Corporation of San Francisco in affiliation with Fred Mannix and Company, Ltd., of Calgary. The 336-mile leg from Regina to Gretna was completed by Williams Brothers Corporation of Tulsa, and Anderson Brothers, Houston, completed the 322-mile contract from Gretna to Superior. In addition, Williams Brothers Corporation (Canada), Ltd., completed the 30-mile section between the Redwater and the Edmonton pump station. Sparling-Davis Company, Ltd., handled the South Saskatchewan river crossing. Other main river crossings were made at the North Saskatchewan river near Edmonton and the Battle river near Hardisty, Alberta. Pipe with ½-inch wall thickness was selected for the crossings and concrete river weights were added to keep the pipe in the river bed and prevent movement during flood periods.

Along the line are six pump stations—at Edmonton, Kerrobert and Regina, Sask., Cromer and Gretna, Man., and Clearbrook, Minn., which are geared to handle up to 95,000 barrels daily as far as Regina. After

Interior of pump station at Edmonton showing installation of 1080-horsepower engines which will power the centrifugal pumps.

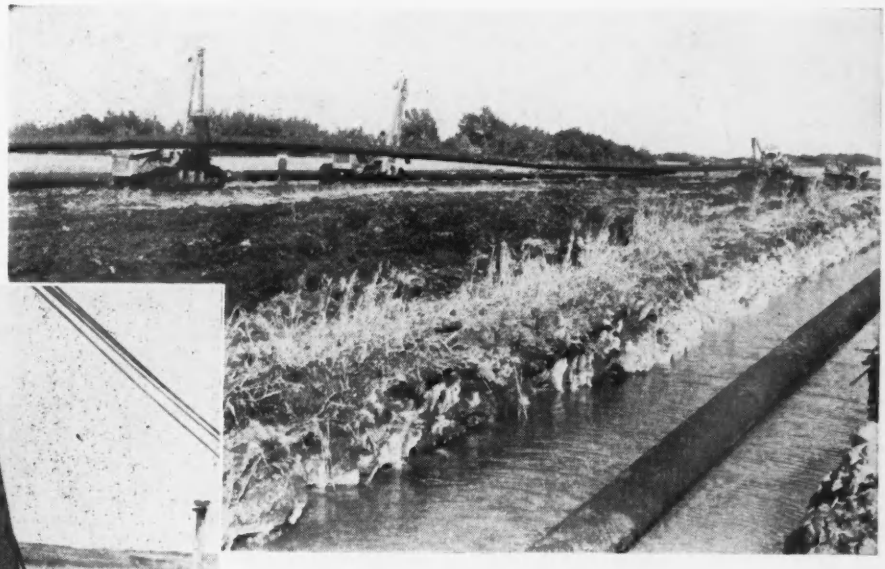
(H. Pollard Photo)



(H. Pollard Photo)

Head of pipe line at Redwater field. Crude is pumped from here to Edmonton where it enters the main line for the trip east.

Sections of pipe are welded together on high, dry ground and floated down water-filled ditch through swampy terrain.



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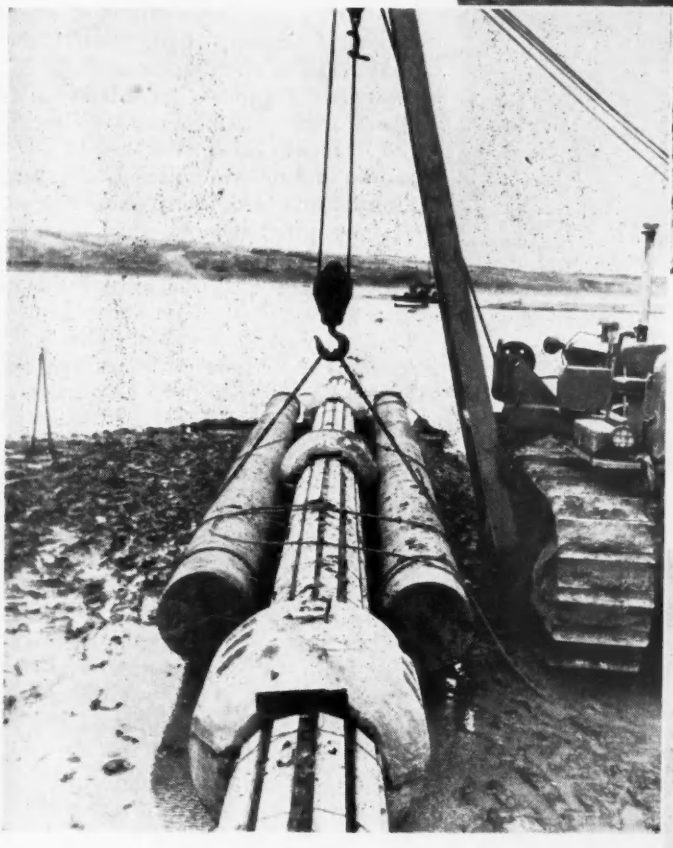
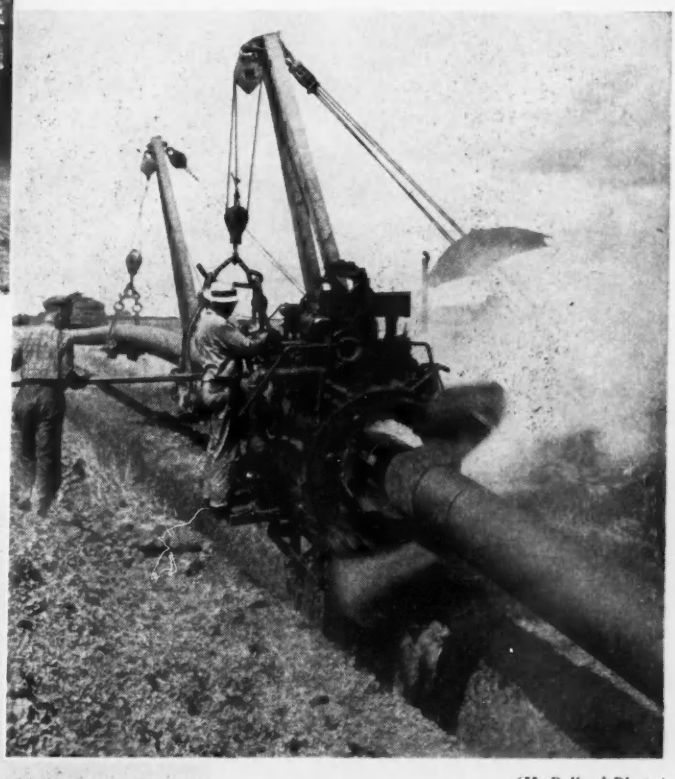
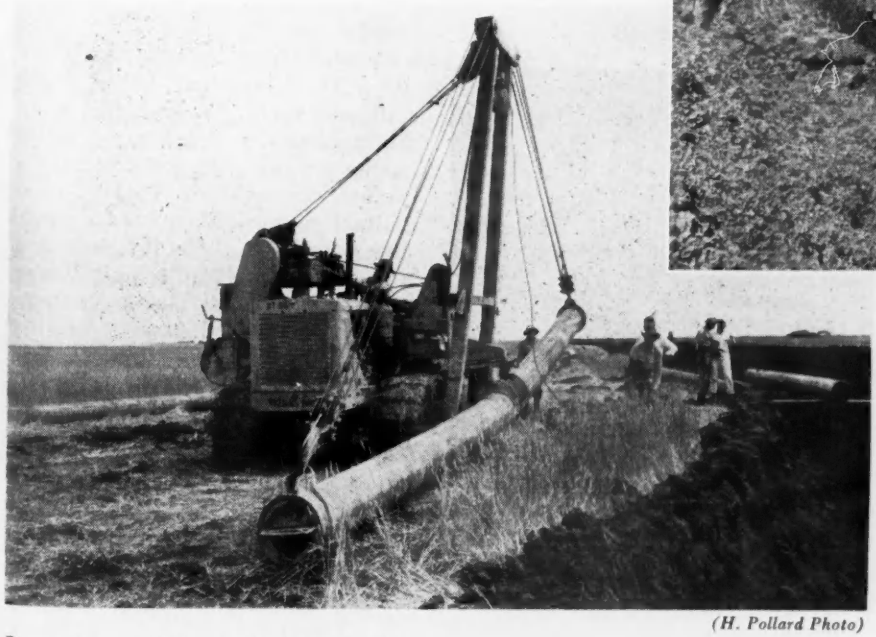


Special techniques involving concrete river weights, pontoons and a battery of side-boom tractors were used in burying pipe in the river bottom across the South Saskatchewan River, near Outlook, Sask.



Pipe wrapper applying coal tar enamel, glass fiber and asbestos coatings on Canadian Big-Inch.

(H. Pollard Photo)



Pipe bending machine in operation along the Interprovincial Pipe Line. Flat country here hastened the laying of the line.

(H. Pollard Photo)

(H. Pollard Photo)

Highway and rail crossings were made for the pipe line with boring machines shown.

Stringing pipe along Interprovincial Pipe Line right-of-way in sub-zero weather.

To lay the pipe across the soft muskeg it was laid atop the surface, relying on the thick matting of roots and brush to support it. The pipe was carried as far as possible with side-boom tractors, then laid down and a second section was welded to it.

withdrawals for Saskatchewan and Manitoba refineries, about 55,000 barrels daily is expected to reach Lakehead. During 1951 six additional pump stations, to boost carrying capacity by 50 percent, are scheduled for installation.

Much of the equipment was produced by Canadian manufacturers, some of it for the first time. Engines were produced by Dominion Engineering Company, Ltd., which also produced the speed increasers. Other Canadian suppliers included Fiberglas Canada, Ltd., Foster Wheeler, Ltd., Horton Steel Works, Ltd., Canadian Johns-Manville, Ltd., and Philip Carey Company, Ltd. Five of the pumping stations in Canada—at Edmonton, Kerrobert, Regina, Cromer and Gretna—were built by Bird Construction Company, Ltd., a western Canadian firm. The sixth station, at Clearbrook, was built by Walco Engineering and Construction Company, Tulsa.

Because of extreme weather conditions encountered throughout the pipe line route, pump station buildings are of steel and masonry walls and unitized as much as possible. The buildings, approximately 75 x 200 x 24 feet high, are heated from waste heat boilers, one to each engine, absorbing heat from the exhaust gases and generating steam at approximately 15 pounds pressure, supplemented by automatic oil fired boilers.

Three complete pumping units operating in series provide the greatest flexibility of operation under all load conditions, with good operating economy at an appreciably lower first cost. This in-series setup comprises a diesel engine of sufficient horsepower driving through a speed increaser to a single stage centrifugal pump. Diesel engines, or dual fuel engines, where natural gas is available, were chosen after studying factors involved.

For the Edmonton and Kerrobert stations, four units consisting of four dual fuel engines, each rated at 1080 horsepower at 600 revolutions per minute driving four 8 x 10 x 6 centrifugal pumps, have been installed thus providing a standby unit at all times. At the Regina and Cromer stations three 810 horsepower units have been erected and provisions made to install the fourth as a standby unit. The Gretna station has three 540 horsepower units and at the Clearwater station there are two 810 horsepower units.

The design is the "closed system" type with no relief tankage floating on the line. Instrumentation has been

■ CONTINUED ON PAGE 208

Discussion of

Crankcase Explosions

J. D. JONES

Master Mechanic, Tulsa Pipe Line Division, Gulf Refining Company

MR. COOK is to be congratulated on being very frank in discussing the problem of crankcase explosions of engines under his supervision. More such discussions might have the tendency to bring together certain facts that could possibly suggest a solution to the problem. I most heartily approve of Mr. Cook's suggestion that all crankcase explosions be carefully investigated and all facts recorded for future information and guidance. If it were not possible to have them published in the trade journals individually, a tabulation or summary of the circumstances surrounding each explosion would be of benefit to both the engine builder and operator alike.

If Mr. Cook's assumption regarding the action of the piston rings is substantially correct, it ought to provoke some thinking on the part of piston ring manufacturers in the direction of providing a ring that will more readily conform to the contour of the cylinder liner irrespective of the pressure within the cylinder and/or the condition of the liner. I would like to ask Mr. Cook if the tests he mentioned are on two- or four-cycle engines and if he ran any tests comparing the performance of the standard conventionally designed ring against that of a two-piece ring.

Improving the ventilation, and the installation of explosion valves, takes care of one of the causes leading to crankcase explosions. It may be that mechanical derangement of the engine's moving parts may be solved by a revision of the inspection schedule and maintenance routines which is customarily followed in the care of conventional stationary engines.

It has never come to my attention that any locomotive-type diesels have suffered crankcase explosions. If that be true, the thought suggests itself that the completely different method of operation may lend itself to newer and better design or maintenance methods.

If it is true that crankcase explosions do not occur as frequently in gas engines as in diesel or dual-fuel engines, and if Mr. Cook is correct in his analysis of the gas engine crankcase conditions, may it not be reasonable to assume that the safer policy is to maintain a too-rich mixture in the crankcase, rather than a lean mixture potentially dangerous in the event of mechanical derangement?

Regarding the design of explosion valve submitted by Mr. Cook, I would like to ask if the presence of the torn gasket after the valve operation impaired in any way the seating of the valve after the explosion pressure was relieved? Also in the tests on the valve, would an operator be burned had he been near the valve at the time it operated?

EDITOR'S NOTE: *The paper on crankcase explosions which was presented at the annual meeting of the Petroleum Division, American Society of Mechanical Engineers in New Orleans, and which appeared on pages 213-216 of* WORLD OIL *for November, 1950, aroused widespread discussion among pipe line engineers and designers of heavy-duty engines. Typical of the reactions to the paper are the written discussions, received at the meeting in time to be read following presentation of the original paper. In order to preserve the viewpoint of each critic, the discussions are presented as read, without reference in their printing here to the order in which they were read.*

RALPH L. BOYER

Vice President and Chief Engineer, Cooper-Bessemer Corporation, Mt. Vernon, Ohio

MY INVITATION to discuss Mr. Cook's paper is appreciated and I am happy to add any remarks from our experiences that might help in any way to assist in the drive to bring this subject fully out into the open. Mr. Cook has had an extremely wide experience in the operation of internal-combustion engines and his opinions are always respected. In this case our experiences do not fully parallel those he reports, but we have no hesitation whatever in disagreeing with him on any points, knowing him to be the broad-minded man that he is. He is sincerely looking for the truth, as we are also, and some day we will fully agree, because we will know more about the problem than we do now.

We certainly agree with him that fully enclosed cases, whether they be on internal-combustion engines, or any other machinery, have been largely responsible for such explosions. Quite naturally, an open frame engine couldn't very well have a crankcase explosion, even though it could have a fire. Fully enclosed machinery is in these days a necessity and it is our job, therefore, to attempt to cope with this problem that has paralleled such design. We fully agree with all of the cited reasons, except the extremely thin babbitt bearings. Our experience has definitely been that they aid in helping to eliminate such explosions, since bearing failures with the thin babbitt are so much less frequent. It is quite possible that Mr. Cook's experience to the contrary might have been caused by some attempts to make thin-wall babbitt bearings without full access to present methods of bonding.

The most complete survey of the subject of crankcase explosions, as far as we know, has been made by the

American Bureau of Shipping, and has therefore been confined quite largely to marine engines. A thorough investigation of each and every report of an explosion, even on many stationary installations, has been made by the bureau and the conditions have been tabulated. Meantime, assistance of the Diesel Engine Manufacturers Association was requested by the American Bureau and at a number of chief engineers' meetings of DEMA where the engineers of the various engine builders were assembled around a table, this subject has been discussed and all known cases brought out into the open.

While there are exceptions, it may be stated definitely that practically all of the reported explosions have been on engines with some form of forced ventilation. Mr. Cook's experience has quite definitely indicated to him that ventilation may be of assistance. We readily agree that if it were possible to use a very considerable quantity of air, feeding it constantly through a crankcase, we should then get a very lean mixture which should not be explosive. We believe, however, that there are two possible pitfalls to this principle. The quantity would have to be quite large and the result of heavy forced circulation would immediately result in excessive lubricating oil consumption, so that one would be tempted to drastically reduce it. A point of greater importance would seem to us to be that most explosions result from hot spots on such parts as camshaft bearings, gear bushings, auxiliary drives, etc., which are almost always in pockets which are not reached by forced ventilation. It would seem therefore, that explosive mixtures are likely to be present in such pockets and the feeding of fresh air through the crankcase would merely supply oxygen to perpetuate an explosion or fire.

The theory as to whether a crankcase is normally rich or lean is of little importance, except as it affects the practice of ventilation and the practice of removal of crankcase doors after an engine has been shut down. Most of us believe that the crankcase is normally over-rich. We fully realize that it does not so indicate in any sort of sample taken from the crankcase, but there is a very sound reason why that should be true. The oil in the crankcase is normally in the form of mist, or fine droplets, as Mr. Cook indicates. In that form it is not an explosive mixture. Any localized area of heating will vaporize the oil in that vicinity and immediately make an extremely rich mixture, probably much too rich to burn with any violence. The oil and air mixture of any given area when changed by heat to a vaporized oil and air mixture is certainly much too rich to propagate an explosion. The admission of air to that area immediately leans it until it can easily be a very explosive mixture.

The above is of course pretty much theory. It is all borne out, however, by the fact that a very large percentage of explosions consists of primary and secondary, the primary being of little consequence, unless it ruptures the crankcase, the secondary being of violence if air has in the meantime been admitted. The accurate listing by the American Bureau very definitely bears this out. We are compelled, therefore, to continue to believe that it is unwise to ventilate the crankcase and disastrous to remove the crankcase doors for a few minutes after shutting down.

We have built over a period of years more gas engine horsepower than diesel. Most of these gas engines are spark-ignited, although in recent years quite a percentage of them have been dual fuel. While a crankcase explosion on a gas engine is not unheard of, we can definitely state that we have had far less evidence of it on gas engines than on diesels. Mr. Cook is quite right that gas engine crankcases always show certain percentages of gas and therefore show certain degrees of explosive mixtures, while diesel engine crankcases do not. Our belief is that this adds still further to the theory that the crankcase is normally over-rich. We have exactly the same oil conditions in the two engines, but in the case of the gas engine the presence of gas adds to the richness, making it still more so. This again is theory, but seems to fit our field practice.

We agree thoroughly with Mr. Cook that each and every engine should be provided with adequate relief valves. We further agree that all relief valves should be quick-seating to prevent an in-rush of air and that they must be protected by a thin gasket to prevent oil leakage. We certainly have no disagreement with him in his decision to provide more relief area than that recommended by DEMA. Our experience is that the recommendation is adequate, but one can't have too much area. The only question we would have on the design of valve he shows is whether or not it operates quickly enough. We have the feeling that it is better to provide much lighter valves, in order to get much quicker action. The valve we use on all our engines consists of a number of feather-weight strips of steel, which are very quick acting and quick seating and these in turn are protected by a blowout gasket, exactly as he indicates in his design. Another point of design, which we have adopted, is that of making certain that the openings from such valves are pointed downward for a maximum protection to operators that may be standing near a valve when it relieves. We had one case where an operator was slightly burned, because he was in that position when an explosion occurred. The valve operated quickly, no damage was caused to the engine, or to any part of the building, but there was flame from the relief valve, so we believe this should be directed downward and away from anyone standing nearby.

S. C. PHELPS

Division Engineer, Interstate Oil Pipe Line Company, Tulsa.

I WOULD like to congratulate Mr. Cook and the Service Pipe Line Company for such an excellent paper on a little discussed, but very vital, topic to all concerned with the building and operation of internal combustion engines. I would like to commend Mr. Cook and his associates on the excellent test work they have done in analyzing crankcase mixtures as to their content of inflammable gases. (It is my understanding that they have sampled gases from almost every engine on the vast Service Pipe Line System, including the company airplanes. It is rumored in Tulsa that, since finding an explosive mixture in airplane engine crankcases, Mr. Cook has grounded himself from riding in airplanes.)

In general, I agree with the approach and proposed protective measures as advanced by Mr. Cook. I would like to inject another approach as to why explosions are more common in certain types of engines than in others. This is based entirely on analytical reasoning from available information on explosions which, as Mr. Cook points out, has been very meager. The majority of explosions seem to occur in engines employing a dry crankcase with an external lube oil sump. These engines may be either gravity feed or pressure-lubricated engines. In this type of engine, the wetting and cooling effect of the lube oil supply held in a wet crankcase engine is lost, thus when a mechanical failure occurs, the dissipation of heat is slower than in a wet crankcase engine, thus increasing possibility of an explosion. The heavier splash in a wet crankcase engine may also be instrumental in maintaining an overly rich mixture surrounding bearings and other local heat points.

This is the most plausible explanation of why crankcase explosions are

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more common in large diesel engines than automotive type engines, as the majority of large diesels are of the dry crankcase type. Explosions in the automotive type diesel and gas-gasoline engines with wet crankcases are relatively rare.

At the beginning of his paper Mr. Cook cites modern trends which add to the possibility of overheated surfaces. To this might be added one modern improvement which has decreased possibilities of overheated surfaces. That is the floating pin piston. Elimination of distorted pistons, caused by driving piston pins, has greatly reduced scored pistons and liners. Simultaneous improvement of piston pin bearing design and materials has reduced possibility of ignition from piston pin failures.

As Mr. Cook points out, two conditions are requisite for a crankcase explosion, namely, a means of ignition and an explosive mixture in the crankcase. Some operators contend that blowby may be a source of ignition. In the writer's opinion, for this to be true, an engine would be in worse mechanical condition than it is conceivable to find under present day maintenance and operation standards. The most conceivable and the definitely determined source of ignition in so many crankcase explosions is mechanical failure of some engine part. As long as rotating and rubbing parts are enclosed in the crankcase, this source cannot be eliminated. Improved maintenance schedules, more skilled maintenance and operating personnel, better and more frequent inspections, etc., can reduce, but never eliminate this as a possible source of ignition.

The second condition, as pointed out by Mr. Cook, will exist from blowby or vaporization of the lube oil at various times in an engine unless special precautions are taken. The chance of an explosive mixture occurring in a crankcase can be eliminated or sharply reduced by purposely making the mixture too rich or too lean to explode. To create a mixture too rich would require a sealed crankcase flooded with methane, butane or other hydrocarbon gas. This is certainly not acceptable in most operations. As Mr. Cook points out, flooding the crankcase with gas creates a potential explosive condition each time a crankcase is opened for maintenance, which may endanger an entire plant and potentially be more of a hazard than the possibility of a crankcase explosion. In certain engines with unsymmetrical piston movements, provisions for breathing must be provided if the crankcase is sealed. The sealed crankcase would require that the gas pressure be maintained slightly above atmospheric to prevent air leaking into the crankcase; hence, higher lube oil consumption, more carbon formation, more frequent piston and ring jobs, and higher maintenance costs can be expected.

To reduce possibilities of explosive mixtures by attempting to keep the mixture too lean to explode can be accomplished in one of two ways. First, the crankcase may be sealed and flooded with carbon dioxide, nitrogen, or other inert gases. Cost of the gas and the disadvantages of a sealed crankcase, as previously discussed, would prevent this from meeting with favor by the majority of operating personnel.

Second, the crankcase mixture may be kept too lean to explode by ventilating the crankcase as outlined by Mr. Cook. This appears to be the most practical solution and is in relatively common practice. This is easily done by connecting the crankcase to the engine air intake, using separators or other means to prevent lube oil being drawn into the air intake. Such connections exist on a lot of engines in which crankcase ventilation is not secured, because no air inlets to the crankcase are provided. Air inlets should be protected with filters and strategically located so that the air sweeps the entire crankcase when traveling from crankcase inlet to the air intake duct. Particularly where multiple crankcase to air intake connections are used, multiple air inlet points will be required. These inlets should be located so that the air stream will pass over as many bearings and moving parts as conditions permit. Great care should be taken to prevent eddy pockets where an explosive mixture might accumulate in some remote location in the crankcase. The ventilation system will, of necessity, have to be planned for each model engine.

With the danger of an explosion reduced to a minimum by better maintenance and crankcase ventilation, it must be conceded that a possibility of an explosion will still exist. To protect operating personnel, the engine, and the remainder of the plant, the relief valve seems to be the best answer to date. Several engine manufacturers are at present furnishing various types of relief valves; however, Mr. Cook has pointed out the shortcomings of some of the commercially furnished valves. Mr. Cook's explanation of the action of the relief valves they are using and the test data he has cited certainly merits consideration by anyone considering installing relief valves on engine crankcases. It is doubtful if engine manufacturers would ever standardize on an engine accessory.

The other possible solution for protection in case of crankcase explosions would be, as Mr. Cook suggests, for engine builders to design crankcases with sufficient strength to withstand an explosion. This, in all probability, would be practical only in the smaller automotive engines. As this is the type of engine where explosions are a rarity, it is doubtful if purchasers could justify the additional cost of such construction.

Interstate Oil Pipe Line Company has had only one crankcase explosion in recent years and is the only case on which any record was made. This occurred in a 275-horsepower V-12 natural gas fuel, spark-ignited engine. This is one of the few wet sump engines, in the knowledge of the writer, in which a crankcase explosion occurred. Source of ignition was positively determined to be a rear main bearing that failed. The explosion blew off 11 of the 12 valve covers, which knocked several holes in the corrugated iron roof. No other damage could be attributed to the explosion. No personnel was injured, although several men were working on and near the engine. The crankcase mixture was not analyzed, but in the writer's opinion, was probably very lean as the engine had run only a minute or two before the explosion and contained both natural gas and lube oil vapors. The mechanics reported a fire was burning in the crankcase after the explosion and removed a crankcase inspection plate and extinguished the fire with a CO_2 extinguisher. The fire flashed back and re-ignited two or three times before it was finally extinguished. Had the crankcase mixture been very rich a second explosion would undoubtedly have occurred when the crankcase inspection plate was removed, and air allowed to enter the crankcase. It is assumed that the flash-back fires were supported by lube oil being vaporized by the main bearing that hadn't had time to cool. It is easy to see the potential danger spot in which the men removing the inspection plate placed themselves.

The proper procedure to extinguish such a fire has not been determined. To flood the crankcase with the CO_2 through the lube oil filling connection is not without danger. A possible solution would be to tap the crankcase and provide a pipe connection with a valve to which half of a quick connection coupling could be attached, with the other half of the coupling on the fire extinguisher hose. Thus, the extinguisher could be connected, the

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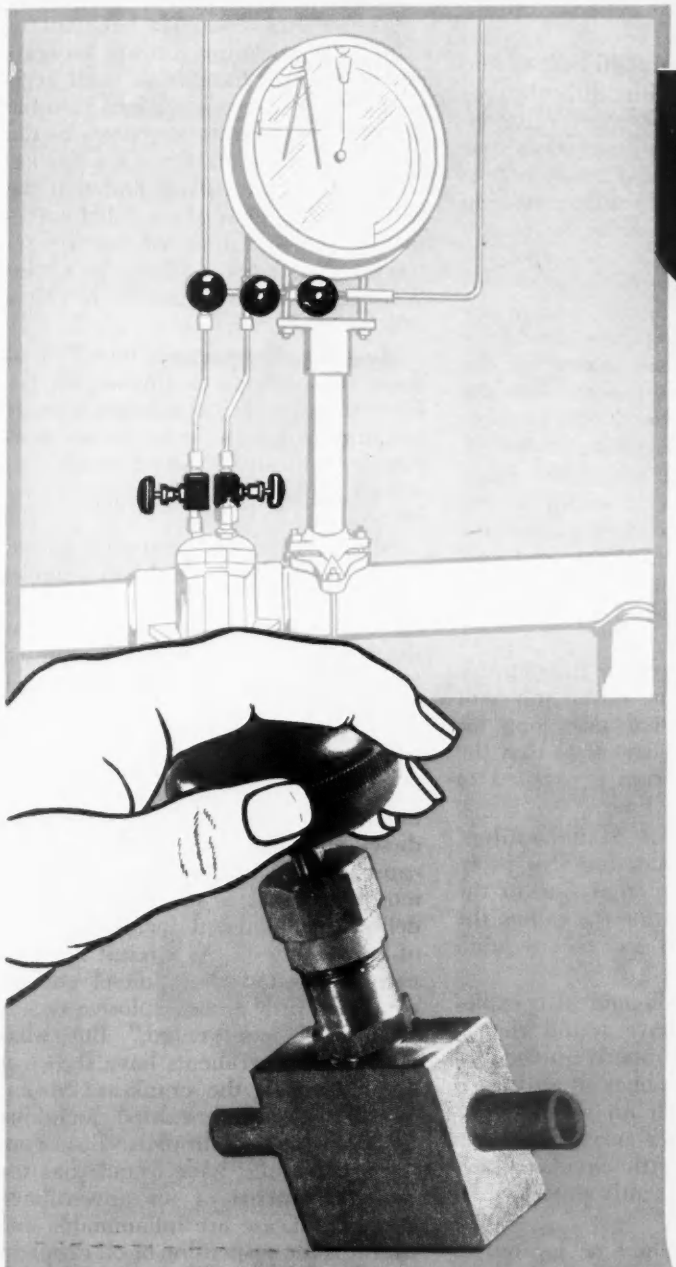

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valve opened, and then the extinguisher discharged into the crankcase. This has not appeared practical in our operations, as usually the first explosion extinguishes the flame and the danger of fire or a second explosion is eliminated by allowing sufficient time before the crankcase is opened. A possibility of a second explosion surely exists if a fire is allowed to burn in the crankcase unless the first explosion has wrecked the engine to such an extent that the crankcase is, in effect, open.

In conclusion, I wish Mr. Cook success in his appeal to engine operators and builders to publish case histories and accumulated data and research on this subject. There is no doubt that more research needs to be done on the cause of crankcase explosions and prevention methods. Perhaps among the interested societies and individual engine builders, a research program could be initiated.

GEORGE STEVENS
Worthington Pump & Machinery Corporation, Harrison, N. J.

I THINK we are in general agreement on the underlying cause for crankcase explosions and it should be strongly emphasized that they are not confined to internal combustion crankcases.

It is quite possible that the higher operating temperatures of internal combustion crankcases contribute somewhat to the possibility by comparison with other mechanical equipment where these higher crankcase temperatures do not exist.

The writer recollects, however, one specific case of a large horizontal air compressor crankcase in which an explosion took place and the only contaminant was the lubricating oil. Heat generated in a crosshead was the source of ignition and the lubricating oil which was a blended type probably created an explosive condition more readily by some of the lighter ends evaporating than might have been the case in a pure mineral base stock product.

Mr. Cook mentions that all natural gas engines with crankcases vented only to the atmosphere were found to contain explosive mixtures, whereas diesel engines contained little or no explosive mixture even when not vented. He also suggests the possibility of leakage into the crankcase during the compression stroke, a condition which no doubt exists since no piston rings can be positively bottle tight.

This leakage tendency would probably be less in high speed equipment than in low speed equipment.

I wonder if Mr. Cook has noticed any difference in the analysis of crankcase samples between naturally aspirated gas engines where the air and gas is mixed in the proper proportion in a mixing valve before entering the cylinder and gas engines where the gas is injected separately and mixed with the air in the cylinder during compression.

Passage of air through the engine would probably be quite difficult insofar as producing a homogeneous condition throughout is concerned, and no doubt it would be virtually impossible to create a satisfactory condition in pocketed areas such as the underside of pistons.

The probable reason for more explosions in diesel engines than in the spark-ignited gas engines could be traceable to the same reason for the farmer having more trouble with the white cows than the black cows because he had more white cows.

Under the list of preventive measures, it is felt that it would be extremely difficult to strengthen the crankcases in the medium or larger size engines even in newly designed products to withstand the effect of the explosion.

While tin-plated pistons might prove of some value in the initial stages of operation, it does not take long for the tin plating to wear off so that the cast iron of the piston is exposed to the cast iron of the liner.

The Diesel Engine Manufacturers' Association in considering this problem have concluded that due to the difficulty of eliminating the causes, the best procedure is to endeavor to minimize the effect.

We have experimented with explosion covers and have found that a rectangular plate properly guided and supported by a number of springs is very effective. Such an arrangement provides for greater relief area than can be obtained with circular plates and can be conveniently produced by simple means.

These covers should be located in sufficient quantity along the entire length of the crankcase so that regardless of where the explosion originates there will be adequate protection in close proximity thereto. There have been cases where a rupture disc was provided at one end of a crankcase and an explosion developing at the other end has wrecked metallic members without even affecting the rupture disc.

This is analagous to an explosion in a tunnel, open to atmosphere at one end where the pressure buildup is so rapid that exit to the atmosphere cannot readily develop.

EDGAR J. KATES
Consulting Engineer, New York City

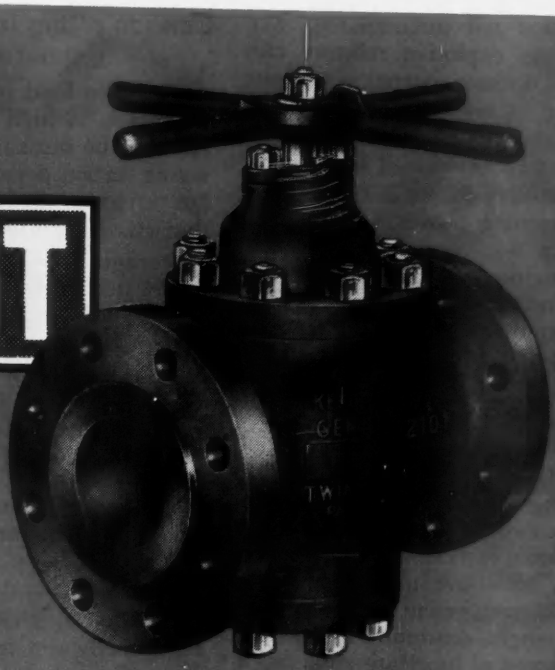
THE author deserves the thanks of everyone concerned with the design and operation of diesel, gas and dual fuel engines for his willingness to disregard the misguided taboo which has surrounded the subject of crankcase explosions. He has made a valuable contribution toward mitigating the serious hazards of such accidents. After studying various possible preventive measures, he comes to the regretful conclusion that crankcase explosions are unavoidable and that the practical answer is to use relief valves such as the well designed type he describes. No doubt, so long as explosions continue to occur, such valves will be beneficial.

However, this writer is unwilling to share the author's pessimism; he believes that if sufficient efforts are made to purge crankcase atmospheres thoroughly by means of forced ventilation, serious explosions can be entirely prevented.

Although the author applied forced ventilation to his dual-fuel engines after crankcase explosions had occurred, he is not sure that this was the proper procedure. His limited faith in forced ventilation is caused, I believe, by his erroneous opinion that the combustible part of the explosive mixture is **always** gas or vaporized oil and never the suspended droplets of lubricating oil. His experiments on diesel engines were inconclusive because he drew off the crankcase atmosphere from a shielded area and deliberately avoided including drops of lubricating oil. As a result he quite naturally found that "diesel engines contained little or no explosive vapors even when not vented." But what would his experiments have shown if he had tested the crankcase atmosphere as it actually existed, including the suspended oil droplets? I am confident he would have found that the normal contents of an unventilated diesel crankcase **are** inflammable and that it is the suspension of oil droplets, not the vapor, which is ignitible.

This is confirmed by laboratory tests made by H. Bara,[1] in which diesel lubricating oil was agitated with air in a non-ventilated chamber and then ignited by a red-hot body. Bara found that flame can be propagated in the atmosphere existing in a normally operated large diesel engine; that ignition can be produced with red-hot metal; that ignition is favored by rise in temperature of the oil bath and by increase in churning effect; that it was the oil-spray atmosphere which ignited; and that the white-mist atmosphere alone, in the absence of oil

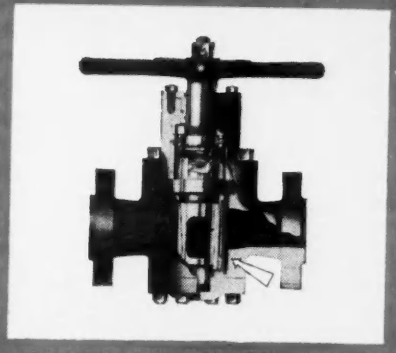
KEROTEST



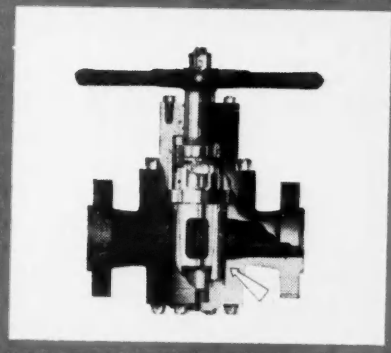
GENERAL

TWIN SEAL VALVE

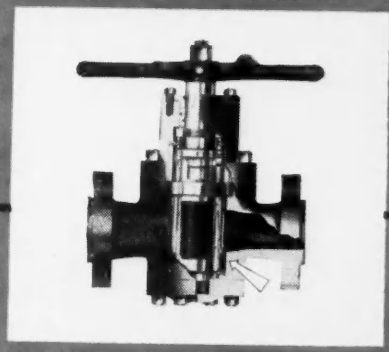
VAPOR-TIGHT SEAL!



● POSITION I—Plug down . . . seats expanded against body ports . . . valve full closed.



● POSITION II—Plug raised . . . seats retracted clear of body wall . . . free rotation . . . no scoring.



● POSITION III—Plug rotated 90° . . . valve full open.

Here is a new expanding seat, tapered plug valve that assures positive vapor-tight shut-off in either flow direction for gas or volatile liquid service. One and a quarter turns operates from full open to full closed position. No lubrication is required. Nothing to score, gall or wear. Renewable seats are replaced quickly through bottom plate. For easy operation . . . positive shut-off and freedom from maintenance, specify the Kerotest General Twin Seal Plug Valve.

1. SHUTS OFF *VAPOR-TIGHT*
2. EASY TO OPERATE
3. NO LUBRICATION
4. QUICK (1¼ turns) OPERATION
5. NO SCORING OF SEATS
   (Seats rotate free of body wall)

WRITE for descriptive booklet giving size and pressure range, and full specifications.

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droplets, was not inflammable. The fact that an explosive mixture can consist of discrete particles without any vapor is also demonstrated by many explosions of flour dust in grain elevators and of coal dust in the pulverizing equipment of power plants.

The foregoing proves, in my opinion, that a non-ventilated crankcase of any engine in which lubricating oil is churned may and often will contain an explosive atmosphere.

In addition, in the case of engines which compress a gaseous mixture, the crankcase contents may become explosive because of blowby during the compression stroke, as the author states.

The author apparently attributes all crankcase explosions to only two sources of explosive mixtures, (a) a gas-air mixture present only in gas or dual-fuel engines running on gas, or (b) a mixture of lubricating oil vapor and air produced when an engine part becomes overheated and vaporizes the neighboring lubricating oil. If these were the only sources of explosive mixtures, straight diesel engines would never explode unless a substantial amount of such local overheating had occurred. But the fact is that diesel explosions have taken place when nothing more than sparks caused ignition. This indicates that an overheated bearing usually causes an explosion not because it vaporizes some lubricating oil and produces combustible vapors but because the hot bearing acts as an ignitor of a previously existing combustible mixture.

In conclusion, it seems to me that forced ventilation of crankcases is the best practical preventative of explosions. Such ventilation, if thorough enough, would purge crankcases not only of the gas-air mixtures which prevail in gas and dual-fuel engines but also of the combustible oil droplets in suspension in all engines including diesels. Furthermore, the cooling effect of the ventilating air would help to prevent ignition. But thorough ventilation means more than merely connecting a pipe from the crankcase to the intake manifold; that by itself only creates a partial vacuum in the crankcase. As the writer has stated elsewhere in more detail,[2] there must also be one or more inlets of adequate size and both inlets and outlets must be so located that an ample quantity of fresh ventilating air will sweep through the entire crankcase.

REFERENCES

[1] Bara, H., Naval Engineer. "The Ignitibility of the Crankcase Atmosphere in Diesel Engines." Second World Petroleum Congress, Vol. III, pp. 494-9, 1937.

[2] Kates, Edgar J. "Let's Ventilate Diesel Crankcases." *Diesel Progress*, July, 1950, p. 42.

Canada's "Big Inch"

■ CONTINUED FROM PAGE 198

designed to hold pressure surges to a minimum. A high flow metering device on the discharge of each station warns station personnel of any major line break or leak downstream from that station.

Storage is provided by six 140,000-barrel storage tanks at the Edmonton station and 12 150,000-barrel tanks at Superior. A dock at Superior water front has been reinforced and dredged to accommodate the *Imperial Leduc* and *Imperial Redwater,* the two largest fresh water tankers in the world. These vessels will move the crude from the pipe line terminus at Superior to the Sarnia, Ontario, area starting with the opening of navigation on the Great Lakes next spring.

The Interprovincial pipe line will carry Redwater crude to Superior for 56 cents a barrel (Canadian), and will carry Leduc, Golden Spike and other Central Alberta crudes from Edmonton to Superior for 54 cents a barrel. Loading charges at Superior terminus aboard tanker will be 3½ cents and the haul from Superior to Sarnia will be about 15 cents a barrel via the big tankers *(Imperial Leduc* and *Imperial Redwater)*. Smaller tankers will charge up to 30 cents per barrel for the same haul. Thus, Alberta crude will reach its first eastern market at about 80 cents a barrel average, or about 29 percent of the cheapest route available without the pipe line. Rail haul from Edmonton to Superior would cost about $2.43 per barrel, with loading and tanker charges increasing the cost at Sarnia to $2.75.

However, in order to compete in the Ontario market, producers of Alberta crude will have to accept a reduction in well-head crude prices, now quoted at $3.20 at Leduc and $2.88 at Redwater. Extent of the reduction will depend on the demand and supply. Meantime, consumers in Manitoba and Saskatchewan will benefit from lower prices for petroleum products made possible through lower transportation costs which result directly from the operation of Canada's "Big Inch" line. Regina refiners, for example, will get oil from Edmonton for 29 cents per barrel by pipe line compared with $1.37 by rail. Rail haul from Edmonton to Winnipeg costs $1.86 per barrel. The pipe line will get oil to Gretna for 44 cents and the 75-mile-long Winnipeg company line will carry it on into Winnipeg for a still undetermined, but low cost. The Interprovincial pipe line assures Ontario and Eastern Canada a long-term supply of Canadian produced oil.

Although producers in the field will have to take less for their crude, the greater volume produced—and increased production made possible by the new pipe line—will increase income of producers an estimated $3 million a month.

Here are some interesting facts about Canada's new pipe line:

The pipe line right-of-way is 60 feet wide. The ditch in which the line is buried was about 3 feet wide and 5 feet deep which meant excavating more than 2¼ million cubic yards of earth.

Approximately 1500 men were employed at the peak of construction and more than $6 million worth of specialized machinery was used.

The pipe line goes under more than 1100 highways, railways and secondary roads in three Canadian provinces and three states.

About 178,000 tons of high-test steel went into the pipe line. Pipe was made up in 40-foot lengths with ends bevelled and joints longitudinally welded and cold expanded by internal hydraulic expansion which substantially increases the yield point. To protect the pipe from corrosion the line is coated with coal tar enamel produced in Canada, reinforced with a glass fiber material and with a coal tar impregnated asbestos wrapper.

Six storage tanks at Edmonton each hold 140,000 barrels of crude giving total storage of 840,000 barrels. Twelve tanks at Superior hold 150,000 barrels each for total capacity of 1,800,000 barrels.

Refineries across the prairies will receive crude deliveries from "take-off points" along the pipe line. Moose Jaw will be served from a take-off at Stony Beach, Sask. Regina deliveries will go right into Regina. Brandon take-off is at Souris, Man., and the Winnipeg take-off at Gretna.

It takes about 26 days for a barrel of oil to move from Edmonton to Superior. The crude moves at about two miles an hour.

It will require 1,800,000 barrels of crude to fill the pipe line between Edmonton and Superior.

The pipe line operates as a common carrier and will move crude for any producer or shipper who meets standard regulations.

ACKNOWLEDGMENT

Information contained in the above article was furnished by Loren F. Kahle, executive vice president, Interprovincial Pipe Line Company, the company's public relations department which also furnished the pictures, and Carl O. Nickle, Calgary.

PIPE LINE *Construction*

By SYLVIA LILLIE, Staff Writer

Projects Announced and Contracts Awarded

Products Lines

Department of El Valle has been authorized by the government of Colombia to build a 105-mile line between Buenaventura and Calif, Colombia.

Plantation Pipe Line Company awarded contract to Williams Bros. Corporation, Tulsa, for the construction of 432 miles of 18-inch from Baton Rouge, La., to Bremen, Ga., and 275 miles of 14-inch from Bremen to Charlotte, N. C.

Natural Gas Lines

El Paso Natural Gas Company has temporary authorization to build 12 miles of 4-inch, 5 miles of 12-inch, and 31 miles of 10- and 16-inch in the vicinity of Phoenix, Ariz.

Hope Natural Gas Company has FPC authority to build 20 miles of 18-inch from its Tonkin compressor station to the Fink storage area, W. Va. Contract has been given to Pipe Line Construction & Drilling Company, Camp Hill, Penn.

Missouri Central Natural Gas Company has applied for permission to lay a 60-mile, six-inch line from Panhandle Eastern Pipe Line Company's system near Hannibal to Macon, Mo.

New River Gas Company asked permission to build 50 miles of line from a connection with Atlantic Seaboard Corporation's system in Summers or Monroe County, W. Va., to Radford, Va., with laterals to serve four towns along the way.

New York State Natural Gas Corporation has been authorized by FPC to build a 164-mile line from its 20-inch line at Dryden to Albany, N. Y.; a 56-mile line from Dryden to the Tioga County, Penn., storage pool; and 70 miles of 20-inch from the Oakford, Penn., storage area to East Ohio Gas Company's facilities at the Ohio-Pennsylvania state line.

Niagara Mohawk Power Corporation has permission to build 15 miles in four laterals from New York State Natural's line to Montgomery, Schenectady, and Albany counties, New York; and ten miles in two laterals from New York State Natural's line to Oneida and Herkimer counties, New York.

Oklahoma Natural Gas Company plans construction of a 65-mile, 26-inch line between Edmond and Depew, Okla., and a 38-mile, 16-inch line, also in Oklahoma.

Tennessee Gas Transmission Company has permission to extend its authorized Kentucky-Buffalo line by 303 miles of 26-inch from Buffalo to the New York-Massachusetts line; to build 786 miles of 24-, 26-, and 30-inch loops along its existing or authorized line from Texas to Buffalo; to build 75 miles of supply laterals; and to install 69,600 horsepower in existing or authorized stations and 42,080 horsepower in seven new stations.

Texas Eastern Transmission Corporation has been authorized to build 35 miles of 30-inch from its system in Fayette County, Penn., into the Oakford storage area.

Texas-Illinois Natural Gas Pipeline Company applied to FPC for authority to lay 43 miles of 20-inch from the area north of La Gloria field northwest to Clayton, Texas; and 26 miles of 20-inch from Clayton south to the Hagist ranch.

Transcontinental Gas Pipe Line Corporation has been authorized to build 35 miles of 24-inch from Berger County, N. J. to Greenwich, Conn.

Venezuelan Atlantic Transmission Corporation has let contract for 220 miles of 12- to 16-inch from central Venezuela to the Caracas-La Guaira area and to Valencia to Williams Bros. de Venezuela, S. A.

Westcoast Transmission Company, Inc., the recently formed American affiliate of the Canadian company, Westcoast Transmission Company, Ltd., has applied for authority to build a pipe line from Sumas, Wash., to Seattle and Tacoma, Wash., and Portland, Ore., and a branch line from Osoyoos, B. C., to Spokane and the AEC plant at Hanford, Wash. These lines will be the American sections of Westcoast's proposed line to serve British Columbia and Washington cities from Alberta gas fields.

Projects Starting

Crude Oil Lines

Amarillo Oil Company is building 12 miles of 10- and 12-inch across the Canadian River north of Amarillo, Texas. Brodie Construction Company, Amarillo, is the contractor.

The Ohio Oil Company started in October 54 miles of 20-inch from Wood River, Ill., to Patoka, Ind. Conyes Construction Corporation, San Pablo, Calif., is the contractor.

Standard Paving Company is building a 15-mile line to serve the Brandon, Manitoba, refinery of Anglo-Canadian Oils, Ltd., from Interprovincial Pipe Line Company's line.

The Texas Pipe Line Company is building 56 miles of 12-inch from Chico station in Wise County to Wichita Falls. R. H. Fulton & Company, Lubbock, Texas, started in November.

Products Lines

Great Lakes Pipe Line Company started in October a 206-mile, 12-inch line from Barnsdall, Okla., to Kansas City. Sparling & Fowler, Edmonton, Alberta, is building 48 miles from Barnsdall to Independence, Kansas; Pacific Pipeline & Engineers, Ltd., San Francisco, is laying 50 miles from Independence to Humboldt, Kansas, and 42 miles from Paola, Kansas, to the Kaw River near Kansas City; A. C. Holder Construction Company, Tulsa, is laying 53 miles from Humboldt to Paola.

Natural Gas Lines

Alabama-Tennessee Natural Gas Company started work the end of October on 35 miles of eight-inch from Muscle Shoals to Decatur, Ala. Lehman-Hoge & Scott, Harlingen, Texas, is the contractor.

City of Danville, Va., is building 14 miles of six- and eight-inch from Transcontinental's line to the city storage tanks. M. L. Bles Construction Company, Danville, is the contractor.

City of Florence, Ala., is building 84 miles of one- through eight-inch distribution system in the city. Modern Welding Company, Owensboro, Ky., started early in November.

Humble Oil & Refining Company started in October 50 miles of eight-inch from Trawick field, Nacogdoches County, to Tennessee Eastman Corporation's new chemical plant southeast of Longview, Texas.

Lone Star Gas Company is building 49 miles of 8- to 12-inch from Jacksboro field, Wise County, to the North Fort Worth measuring station. Company crews are doing the work.

Northern Natural Gas Company is building 42 miles of six- to ten-inch line in South Dakota and Iowa. Bills & Troth Construction Company, Tulsa, began work in October.

Southern Natural Gas Company started in October 40 miles of 18-inch from Selma, Miss., to Elmore, Ala.; and 121 miles of 16-inch from Mitchell Village, Ala., to Bolingbroke, Ga. Associated Pipe Line Contractors, Houston, is building both lines. Sheehan Pipe Line Construction Company, Tulsa, is laying 32 miles of 16-inch in the vicinity of Wetumpka, Ala.

Sunray Oil Corporation started in November 133 miles of two- through 30-inch in the vicinity of Snyder, Texas. Vaughn & Taylor Construction Company, Inc., Wichita Falls, Texas, is the contractor.

Tennessee Natural Gas Lines, Inc., is building a 24-mile line to supply Nashville Gas & Heating Company for distribution in the Nashville area. N. A. Saigh Company, Inc., San Antonio, is the contractor.

Texas Eastern Transmission Corporation is building a 100-mile, 16-inch line from Provident City to Baytown, Texas. Smith Contracting Corporation, Fort Worth, started in October.

Texas Illinois Natural Gas Pipe Line Company is building a 100-mile, 26-inch line from Wharton to Refugio, Texas; and a 38-mile, 12-inch line from Alvin to Angleton, Texas. Western Pipe Line Con-

structors, Inc., Austin, started right-of-way in October for both lines.

Projects Completed

Crude Oil Lines

Amarillo Oil Company completed in October 10 miles of 12-inch from north of Amarillo across the Canadian River. Brodie Construction Company, Amarillo, Texas, was the contractor.

Lakehead Pipe Line Company has completed its 360-mile, 18-inch line from Gretna, Manitoba, to Superior, Wis. Anderson Bros. Corporation, Houston, was the contractor. The 1150-mile line from Edmonton, Alberta, to Superior, built by Interprovincial Pipe Line Company, Ltd., and Lakehead is now completed and in operation.

Phillips Petroleum Company completed in November 55 miles of six- and eight-inch from Sweeny to Humble's station at Webster, Texas. O. R. Burden Construction Corporation, Tulsa, was the contractor.

Products Lines

Dow Chemical Company completed 66 miles of six-inch between Freeport and Katy, Texas. Barry Construction Company, Houston, finished in October.

Natural Gas Lines

East Ohio Gas Company completed in November 24 miles of 20-inch from TGT's system at Petersburg to East Ohio's Austintown, Ohio, station. Tulsa Williams Company, Tulsa, was the contractor.

El Paso Natural Gas Company completed in October 99 miles of 30-inch between Deming, N. M., and Tucson, Ariz.

Manufacturers Light & Heat Company laid 40 miles of six- to ten-inch line in the vicinity of York, Penn. Britton Contracting Company, Inc., Washington, Penn., completed in October.

Mississippi River Fuel Corporation completed in October 40 miles of 20-inch from Bushton to Concordia, Kansas. Construction Company, Inc., Cape Girardeau, Mo., was the contractor.

Northern Natural Gas Company completed in November a 74-mile, 26-inch line from Bushton to Concordia, Kansas. R. H. Fulton & Company, Lubbock, was the contractor.

Phillips Petroleum Company completed 118 miles of 3- to 22-inch gathering system in Sherman and Hansford counties, Texas. Vaughn & Taylor Construction Company, Inc., Wichita Falls, finished in November.

Pure Transportation Company completed in November 100 miles of six inch between Heath and Dayton, Ohio. Wabash Contracting Company, Centralia, Ill., was the contractor.

South Jersey Gas Company completed in November 77 miles of 8-, 10-, 12- and 16-inch from a Transcontinental lateral near Camden, N. J., to Atlantic City, with laterals to Glassboro, Bridgeton, Vineland, and Estelville. G. G. Griffis, Inc., Tulsa, was the contractor.

Southern Natural Gas Company completed in October a 23-mile, 12-inch line from Douglasville to Newnan, Ga. Latex Construction Company of Georgia, Atlanta, was the contractor.

Tennessee Gas Transmission Company completed in October a 93-mile, 30-inch loop from Drew to Holly Springs, Miss., built by Oklahoma Contracting Corporation, Dallas; and a 32-mile, 30-inch loop across the Southeast corner of Arkansas, with Latex Construction Company, Houston, as contractor.

Tennessee Gas Transmission Company completed in October a 95-mile, 20-inch lateral from the main line at Natchitoches to Kinder, La., built by Latex Construction Company, Houston; and a 57-mile, 8-inch line from Greensburg to Brandenburg, Ky., built by Brown & Root, Inc., Houston.

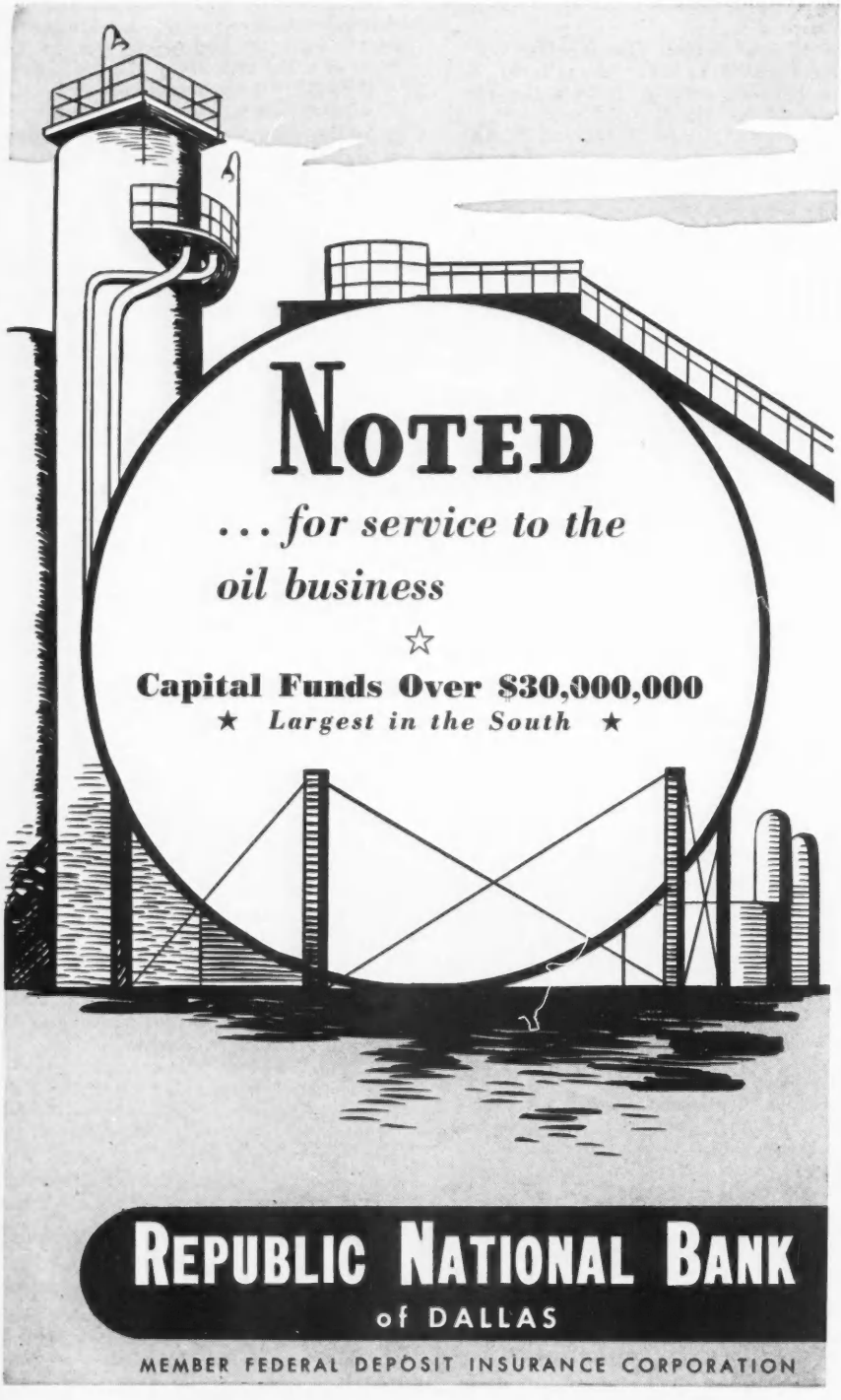
Transcontinental Gas Pipe Line Corporation completed in October two sections of its Texas-New York line: Schedule C—74 miles of 26-inch from Edna, Texas, to the Harris-Fort Bend County line, built by Oklahoma Contracting Corporation, Dallas, and 40 miles of 30-inch from the Harris-Fort Bend County line to Porters, Texas, built by Williams Bros.-Davis Company, Houston; Schedule D—92 miles of 30-inch from Porters to the Sabine River at Deweyville, Texas, built by Texas-Southern Contracting Company, Fort Worth.

United Gas Pipe Line Company finished in November nine miles of eight-inch in the vicinity of Rosenberg, Texas, with Massey Pipeline Construction Company, Corpus Christi, as contractor.

United Gas Pipe Line Company completed 23 miles of 16-inch from Mud Lake field, Cameron County, La., to Port Arthur, Texas. Texas-Southern Contracting Company, Fort Worth, was the contractor.

United Gas Pipe Line Company completed a 41-mile, 12-inch line from Laurel to Meridian, Miss. Brown & Root, Inc., Houston finished in October.

Westcoast Transmission Company Ltd. completed in October 17 miles of 4-inch from Pouce Coupe, Alberta, to Dawson Creek, British Columbia. Standard Gravel & Surfacing Company, Calgary, Alberta, built the line in October.



Rounding the Bends Near Bartlesville

1. **UNIFORM ROUNDNESS**—Pipe ends match up perfectly . . . speed construction . . . cut costs.
2. **UNIFORM DIAMETER**—No "off-size" lengths to cause welding difficulties at joints.
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7. **EASY TO WELD**—Low carbon steel welds readily . . . makes sound joints.
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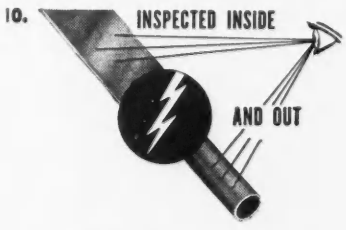
10. 

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. . . Another Republic Electric Weld Pipe Line — 150 Miles Long

● During construction of this 12¾" gasoline line out of Tulsa, a complicated cross-over bend had to be made near Bartlesville, Oklahoma.

Here again, the *high ductility steel* found in every length of Republic Electric Weld Line Pipe proved its value in speeding field bends. This section of the line took the bend in stride and hurried on toward completion.

Easy bending, high ductility steel is but one of the "plus" features this up-to-date line pipe offers you. It's out in front on all 10 counts listed here.

They're the reasons why more than 55,000 miles of Republic Electric Weld Line Pipe have been laid during the past twenty-one years, carrying crudes, gasoline, natural gas and by-products.

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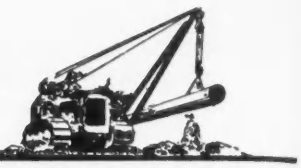
How to do it!

PIPE LINE HINTS



$10 is paid for each illustrated acceptable contribution. Mail to The Editor, WORLD OIL, P. O. Box 2608, Houston 1, Texas

HOW TO—Make Temporary Dolly for Low Bed Float

Mud is always a problem on construction jobs. This is especially true in the case of compressor and pump station construction jobs because of the heavy equipment that must be moved from place to place.

When mud is so deep and slick that trucks are mired, this easily-constructed dolly permits a float to be attached to the draw bar of a tractor, thereby enabling construction crews to continue moving pumps, compressors, tanks, etc., about on the job.

This dolly can be constructed with an axle and fifth-wheel temporarily "borrowed" from an unused float. However, when the dolly is no longer needed, it can be dismantled and these materials returned to the float, undamaged except for one weld on the axle housing. The steel table-like frame is shown bolted to the springs of the axle. This frame, which is about three feet square and six inches deep, has four lugs welded to the sides. These lugs are bolted to the springs.

Extra heavy four-inch pipe extends from this frame to the draw bar of the tractor as shown, and a two-inch pipe brace is welded to the axle housing and to the offset in the four-inch pipe. Of course, the four-inch pipe must be flattened and drilled at one end in order to fit the draw bar of the tractor.

If the low-bed float is equipped with a fifth-wheel, a flat plate can be bolted at proper height to the frame and a king-pin welded in place.

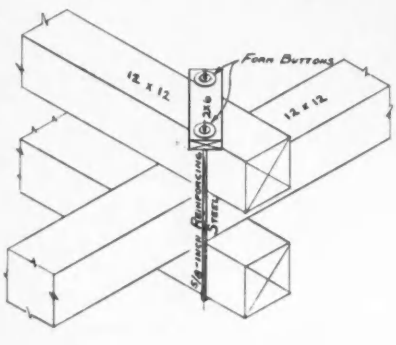
However, if the low bed float has no fifth-wheel, one can be borrowed from unused equipment and bolted on to the dolly as illustrated.

Once a job has been equipped with this dolly, the axle and fifth-wheel "borrowed" from the other units can be quickly interchanged during dry spells for normal use. However, when bad weather returns the dolly can be easily reassembled.

HOW TO—Erect Movable Equipment Loading Ramp

It is often impossible to set a number of gas compressor engines from a single ramp, and a separate ramp must be provided for each engine. Tearing down and rebuilding a ramp for each engine is expensive and time consuming.

Instead of employing the usual method of drilling holes through the heavy timbers and bolting the ramp together, this contractor made large U-bolts out of ⅝-inch reinforcing steel, formed to extend around two or three timbers; then capped the open end of the "U" with a short length of 2 x 6 board and used ordinary form buttons to lock it into place. This eliminates the laborious drilling, countersinking, etc., that would be necessary to bolt the ramp together.



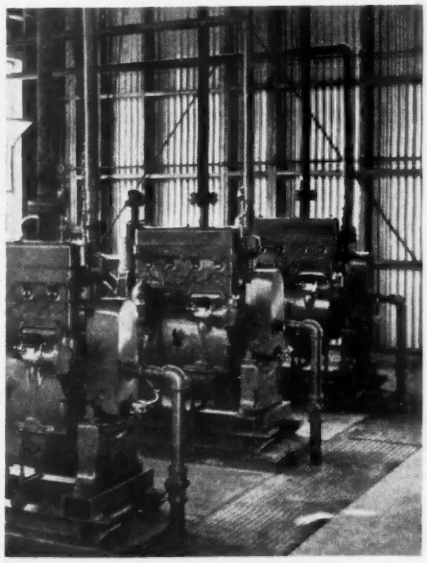
The runners on the ground are hewn at the ends to facilitate skidding, and the rest of the ramp is of cribbed construction—the spacing of the timbers based on the estimated load.

This ramp is sturdy enough to be skidded by winch trucks without damage, provided sufficient number of reinforcing steel U-bolts are used.

HOW TO—
Install System to Cool Engine Battery

Where a reliable supply of water is available at gas transmission booster stations, the cooling system of auxiliary engines can be connected to it at considerable savings. The battery of engines illustrated is driving centrifugal pumps which supply jacket cooling water for 300-horsepower compressors.

The supply water line header is below floor level and is covered over with floor plate. In this trough are other lines that serve the engines and pumps. Risers equipped with valves and reducing ells carry the water to each engine at the point where the radiator normally discharges cool water into the engine. The engine cooling fan has been removed, but the belts driving the water pump are left intact as a safety measure to insure adequate



distribution of cool water inside the engine head. The belts are covered with a metal guard.

The engine cooling water is discharged through a thermostat connected to the discharge line by a rubber hose. The overhead line dumps water into the cooling tower system where it is cooled for recirculation.

In addition to the saving in initial expense by eliminating the radiators on this installation, the heat generated by the engines is removed from the inside of the building, rather than be exhausted there if radiators were used. The overhead discharge line maintains a constant head of water on the cooling system, thereby preventing a complete discharge of water should the supply break down.

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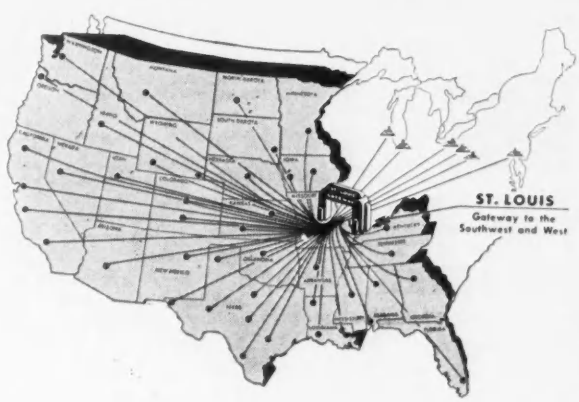

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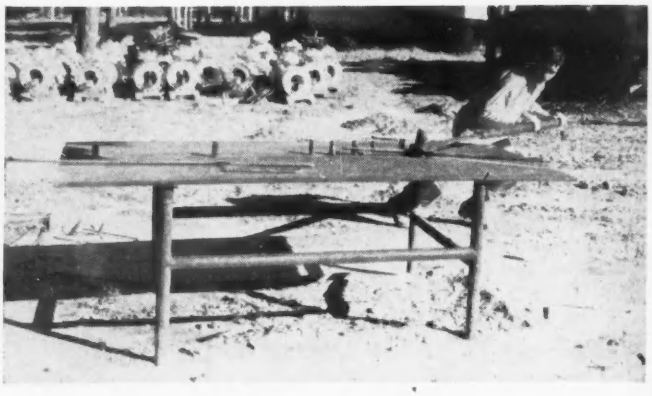
HOW TO—Deform Reinforcing Steel



Specifications covering the construction of gas compressor stations often prohibit the use of heat in deforming the reinforcing steel used in concrete foundations, walls, engine blocks, etc. Cold bending is required. This poses a difficult problem because great force must be applied to bend large size steel.

This excellent bending table permits precision cold bending of all sizes of steel commonly used in this type construction, and at the same time allows the bending force to be applied in such a manner that the steel can be deformed with minimum effort on the part of the workmen.

The table top is 8 feet x 4 feet x ¾-inch steel plate welded to a frame of three-inch pipe. The legs of the frame are set in concrete to hold the table stationary during the bending operation.

A hub around which all the steel is bent is made of a six-inch length of round shaft, sized to give correct radius to the deformations in the steel. This shaft is counter-welded through the table top in the center about two feet from one end.

The bending lever which fits over the hub is made of a ¾-inch steel plate, the lower portion being cut in the shape of a paddle about six inches wide. A short length of pipe sized to fit over the hub serves as a bearing for the lever. A four-

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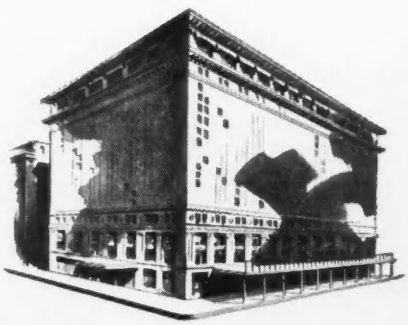

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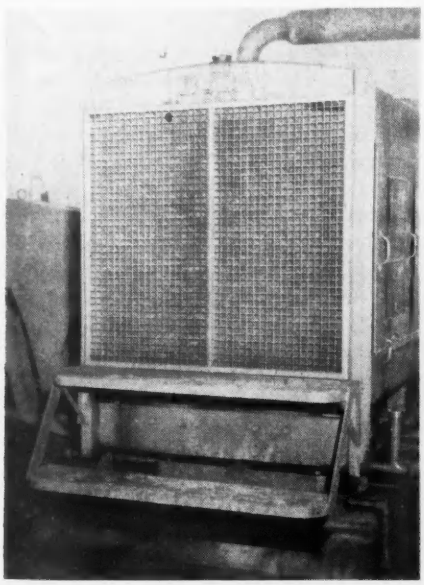
inch sheave mounted a short distance from the bearing as shown rolls the steel around the hub.

Down the center of the table is a row of back-up pegs which holds the steel in place during bending. To locate these pegs, lay a piece of the largest size steel to be deformed down the center of the table top, touching the hub on the side opposite to the direction of bending. Using this piece of steel as a guide, tack weld the pegs in place, spacing the first five pegs about six inches apart as shown.

HOW TO—
Simplify Servicing Engine Radiators

Servicing radiators at pumping stations is facilitated by a pipe line company which equips engines with fixed steps that extend across the full width of the engine front. The two-step unit illustrated provides ample foot room and space for a man to stand on or move about while filling or servicing the radiator.

Use of this type of step eliminates the need for carrying a step ladder from one



engine to another, and because the unit is supported by bolting to the front of the engine, with no part of it resting on the floor, sweeping and cleaning in that area can be done with ease. The unit has treads of floor plate material and is amply braced to support the weight of one or two men. Made up as a complete unit, the step assembly is bolted with two bolts at each end to the side of the vertical channels which extend up the sides of the radiator.

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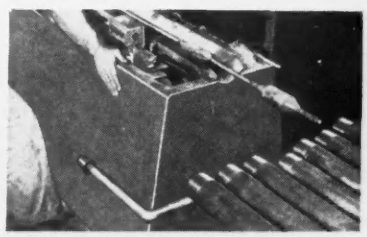
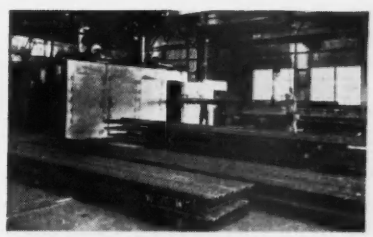
Tube-Kote Prevents Trouble That Starts on the Inside!

The Tube-Kote plant-controlled process of applying "TK-2," thermo-setting (baked on) plastics assures a tough, extremely durable protective coating on the inner surfaces of oil field tubular goods. Prevents corrosion from the inside, ends problems of paraffin deposition, eliminates many costly "shut downs" due to pipe failures.



Tube-Kote fully automatic internal coating unit applies a carefully controlled film of "TK-2" plastic in each coating operation.



A view of the Tube-Kote baking ovens which can handle over 12,000 feet of tubular goods per hour.

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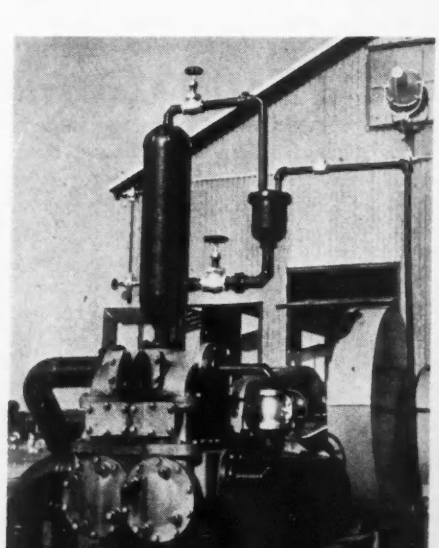
HOW TO—Remove Air From Pipe Line

Slugs of air in a pipe line can do considerable damage to pumps, cause the oil in tanks to bubble, and otherwise create an undesirable nuisance throughout the system. Once oil is moving through a line free of air pockets, it is not likely to pick up air as long as it is under a reasonable pressure.

However, the situation is different in gathering systems which take crude from the lease stock tanks and bring the oil to a central storage point for transfer into the main pipe line. In many cases this oil is drawn into the pumps under a very low head, thereby amplifying the possibility of entraining air in the oil.

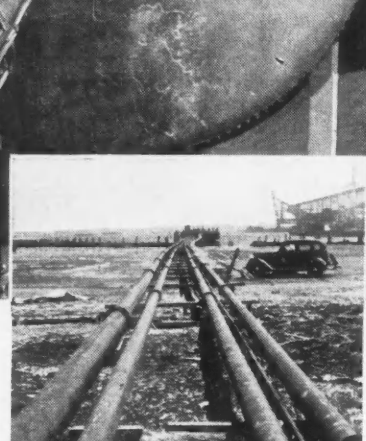


This is a simplified and automatic method of eliminating any air in the gathering system, as well as a device which serves as a surge chamber for the discharge of the oil pump. The gathering pump shown has a ten-inch suction and a six-inch discharge, both at the left of the power end of the pump. The discharge manifold located on top of the fluid end is equipped with three ports: one on either side of the pump and a third on top.

The top opening is fitted with a surge chamber made of 12-inch pipe about four feet long. This chamber is orange-peel welded at either end, with a 1¾-inch connection at the upper outlet. This outlet makes a 180-degree bend, is attached to a float chamber, and is again connected into the chamber at a point below the float as shown. Each connection is fitted with a globe valve.

An air vent line is attached to the top of the float chamber to discharge air or gas from the system. This combination air vent and surge chamber collects air on the discharge side of the pump. Air collects in the chamber, thereby lowering the fluid level. The float in the chamber falls, opening the vent line to the top of the surge chamber while closing the bottom by means of the float valve. As the air is discharged through the vent line, the oil rises to a given level and the vent line is closed, thereby maintaining the surge chamber about half full of liquid and half gases. The device is automatic, and a gauge located on the chamber indicates the height of oil in the chamber to attest the proper functioning of the float valve.

HANDIEST... wherever you have pipe to join



Whether it's an equipment hookup, a field line, or a terminal—anywhere you're joining pipe—the handiest, surest way to get uniformly tight pipe joints is with Dresser Couplings and Long Sleeves.

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1950

Canada's Big Development Year

By MARK OLSON
International Editor

CANADA made tremendous progress as a potential oil producing country during 1950. Most of the advances, in all categories, took place in the province of Alberta, where daily average production for 1949 was 54,609 barrels as compared with 99,593[1] barrels per day for the week ending September 11, 1950. However, oil production by days or by months does not present the true picture of Canada's oil development, for the country's actual ability to produce is held back by lack of adequate outlets for its oil.

To evaluate the work being accomplished by the petroleum industry in Canada it is necessary to study activities other than production. For example, to the end of 1949 the province of Alberta had a total of 1242 producible wells (511 oil wells being completed during the year). By comparison, that figure stood at 1794[1] as of October 2, 1950—more successful wells in eight months than were completed during all of 1949! For the seven-month period ending July 31, 1950, there had been 2,256,979[1] feet of hole drilled in Alberta as compared with a total footage of 3,006,293 in 1949. Monthly footage drilled increased from about 222,000 feet in December, 1949, to 466,000 feet in July of this year. There were 184[1] wells drilling in July of this year as compared with 76 at the end of 1949. As of October 14 of this year 119[2] drilling rigs were operating in Alberta, 46 of them on wildcat wells as compared with 38 wildcat rigs at the end of 1949. In the 273-day

CANADA'S OIL progress stems from the discovery of the Leduc field in 1947 and gained momentum with the discovery of the Redwater, Excelsior, Stettler, Campbell and Joseph Lake fields. With probable proven reserves of about 1.2 billion barrels by the end of 1950, Canada's oil activity is in reality measured in terms of wells drilled, rigs running, geophysical crews in the field, and area under exploration. In fact, because of a lack of adequate outlets for its oil, the Dominion's daily production is no indication of the ability to produce.

period from January 1 to September 30 this year, 702[2] wells were drilled in Alberta as compared with 764 wells for the entire year 1949.

Last year was a banner one for Canada's oil industry, but 1950 will see new records set in all departments. With the continuing expansion of the present large producing fields and the addition of new field discoveries this year, Canada's proven oil reserves will probably increase 20 percent over last year to reach a total of 1.2 billion barrels. In early October the Alberta Geological Survey reported that Canada's proven gas reserves now stand at 7 trillion cubic feet, a 50 percent increase over the estimate two years before.

During September, 120[2] geophysical crews were in the field in Western Canada as compared with 110 such parties at the peak of last year's activity. In Alberta alone the number of parties was 90.[2]

About 190 Canadian and foreign oil companies are operating on about 125,000 square miles of Western Canada's estimated 675,000 square miles of prospective oil territory. Maps in this issue will indicate that the fields discovered thus far have not formed a definite trend in any one direction; therefore, there is little doubt Canada will continue to set new records in oil activity for several years to come.

To appreciate fully the growth of Canada's oil industry, which actually stems from the discovery of the Leduc field in February, 1947 (before which time annual production was a little more than 7 million barrels), it will be necessary to study the growth of the important individual fields from 1948 through late 1950. The fields are listed in the order of their present prominence.

Important Oil Producing Fields

Redwater Field

	Year 1948	Year 1949	Jan. to Sept. 1950[1]
Producible Oil Wells	1	278	578
Oil Production	36,875	4,793,491	5,634,320
Av. Daily Production	307	13,133	23,190
Well Drilling—Period's End	3	15	21
Cumulative Production*	36,875	4,830,366	10,464,686

* From Inception

Discovered in September, 1948, Redwater now has proven reserves in excess of 500 million barrels and is Canada's largest potential producer.

Most recent developments in the Redwater field:

- Fifty oil well completions and one dry hole during August.
- New allowables set at 165 barrels per well per day in October.
- Quarter sections of undrilled land in Redwater now bring bonuses of from $225,000 up.
- Lease holders in Redwater include, Imperial Oil Company, Limited, Anson-Selburn-Pacific Company, Dome Western, Pacific Petroleum Company, Royalite Oil Company, Seaboard Western Minerals, Ltd., Spooner-Tower, Texaco-McColl Frontenac Company, Western Simmons Oil, Ltd., and Federated General Petroleum, Ltd.
- Wells in the field October 16, totaled 674.

Leduc-Woodbend Field

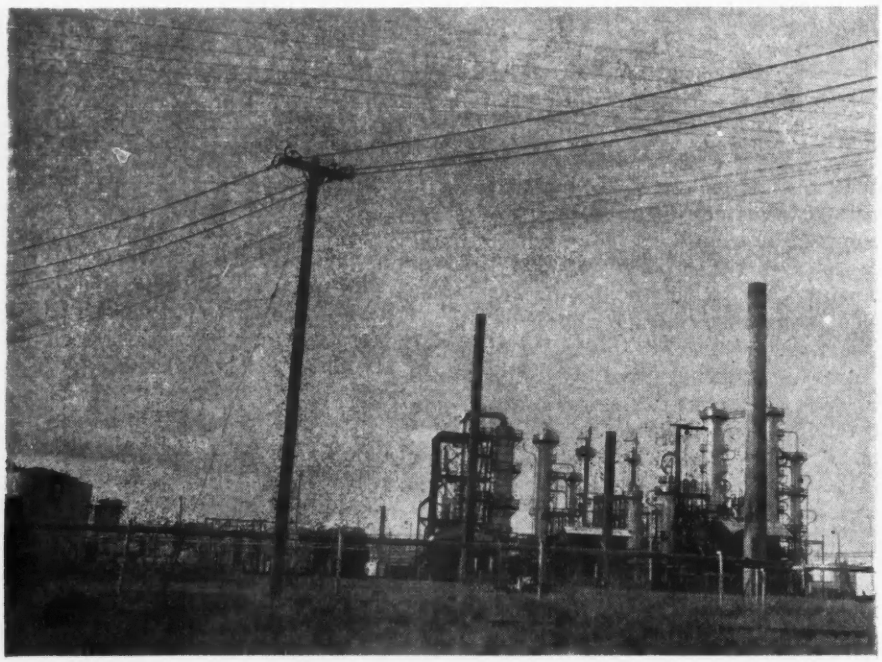
	Year 1948	Year 1949	Jan. to Sept. 1950[1]
Producible Oil Wells	151	351	446
Oil Production	4,657,371	9,688,784	6,880,768
Av. Daily Production	12,760	26,540	25,316
Wells Drilling—Period's End	18	20	29
Cumulative Production*	5,029,798	14,718,582	21,599,350

* From Inception.

The Leduc-Woodbend field is rapidly being drilled up. Discovered in February, 1947, it now has proven reserves in excess of 250 million barrels.

Most recent developments include:

- Total number of producing wells as of October 16 was 480, of which 296 belong to Imperial Oil Company.
- October daily well allowables were set at 110 barrels for the D-3 zone, 70 barrels for the D-2 zone, and 40 barrels for the Lower Cretaceous zone.
- Two gas wells in the field produce an average of 620 million cubic feet per month.
- There are presently 13 Lower Cretaceous zone oil producers, 173 D-2 zone producers and 294 D-3 zone producers in the field.
- Leduc-Woodbend may have received a one-mile northeast extension in September with the completion of a 600-barrel a day well in the Lower Cretaceous in what is now known as the Gilbert field.
- Principal leaseholders in Leduc-Woodbend: Imperial Oil, Hudson's Bay Oil and Gas Company, Bay Petroleum Company, Leduc Consolidated Oil Company, Okalta Petroleum Company, Texaco-McColl, Allenbee-Marlinger Oil Company, Dewar Oil Company, North Woodbend Oil Company and Fliers' Oil Company.



The British-American Oil Producing Company's refinery in Calgary. With a rated capacity of 7200 barrels daily, this refinery will probably be enlarged along with others in the area to handle Canada's increasing oil output.

Turner Valley Field

	Year 1948	Year 1949	Jan. to Sept. 1950[1]
Producible Oil Wells	321	327	329
Oil Production	4,432,084	3,826,543	2,256,407
Av. Daily Production	12,142	10,484	9,285
Wells Drilling—Period's End	2	2	3
Cumulative Production*	91,093,287	94,919,830	97,176,237
Producible Gas Wells	.....	71	77
Avg. Monthly Gas Prod.	.....	2.5 billion c.f.	2.3 billion c.f.

* From Inception.

The decline of Turner Valley is readily apparent from the above data. Discovered in 1914, the field's estimated remaining recoverable reserves are 25 million barrels.

Recent activities include:

● Production for the field has been estimated as due to drop from about 4 million barrels this year to 1.5 million barrels in 1960.

● Two oil wells were completed in the field during August, each testing about 130 barrels per day.

● Crude oil in place in the field has been calculated to be between 750 million and 1 billion barrels, of which about 15 percent will be recovered by present methods. Because of this huge calculated reserve, Royalite Oil Company, Ltd. started a water-flooding program in 1948, which has not yet furnished conclusive results as to its effectiveness.

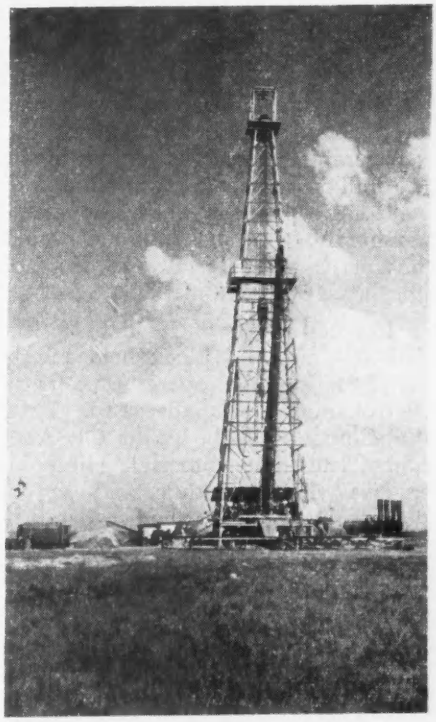
● Principal leaseholders include: Royalite Oil Company, Ltd., Home Oil Company, Ltd., Gas and Oil Products, Ltd. Group, Well Operators, Ltd. Group, Commonwealth Petroleums, Ltd., National Petroleum, Ltd., Davies Petroleum, Ltd., and British Dominion, Ltd.

Lloydminster Field

	Year 1948	Year 1949	Jan. to Sept. 1950[1]
Producible Oil Wells	182	231	243
Oil Production	1,497,221	1,499,036	1,244,749
Av. Daily Production	4,102	4,107	5,122
Cumulative Production*	2,601,130	4,100,166	5,344,915

* From Inception.

Lloydminster has been finding a better market for its heavy crude in recent months. With its oil usage limited to bunker fuels, highway topping and asphalt products, the field has more or less been the ugly duckling of Western Canada's oil industry since its discovery in 1940. The field is almost evenly divided between Alberta and Saskatchewan, as are the number



Wildcat rig in western Saskatchewan. The province is being tested for oil along most of its western boundary.

of wells and the production. Alberta's 103 wells produced 75,125 barrels during July, while Saskatchewan's 140 wells produced 96,095 barrels, according to the Meanwell Accounting Service of Lloydminster.

Among the major lease holders of the field are, Franco Oils, Ltd., Commonwealth Petroleum and Associates, Ibstone and Saskatoon Group, Husky Oil and Refining Company, Ltd., Lloydminster Oil Producers, Ltd., Superior Oil-General Petroleum Group, Van Lloyd and Cardinal, Ltd., and Petrolmine Exploration, Ltd.

An added boost to Lloydminster productive incentive was the recent announcement that the price of the "black oil" had been raised a net 25 cents a barrel at the refinery.[2] The new price was retroactive to October 1, and makes the going price for the 8- to 20-gravity crude range from $1.40 to $1.52 a barrel.

Excelsior Field

	Year 1949	Jan. to Sept. 1950[1]
Producible Oil Wells	1	22
Oil Production	1,616	114,891
Average Daily Production	52	473
Wells Drilling—Period's End	1	1
Cumulative Production†	1,616	116,507

† From Inception.

There may be some question about placing this field ahead of the Golden Spike as to importance insofar as production is concerned. For example, the Excelsior field produced 24,648 barrels in July this year as compared with 41,532 barrels for Golden Spike. However, Excelsior has seven times as many producing wells as Golden Spike, one-ninth the per-well allowable, and thus far has not had the development limits determined.

When the new allowables were issued in October, Excelsior wells were assigned 105 barrels daily per well. Imperial Oil Company voluntarily cut its 16 wells in the field to 67 barrels daily each.

Discovered late in 1949, Excelsior is far from fully developed. The map on page 300 will indicate that drilling might still be wide open to the northeast, east and south. As in most of the other fields in Canada, development is held back until adequate outlets are available for the oil. When storage was being built up at Edmonton for the opening of the first link in the Interprovincial Pipe Line, Excelsion produced up to 1280 barrels per day, in late September.

Principal leaseholders in the field are Imperial, Rio Bravo Oil Company, Dome Exploration, Ltd., Metro Oils, Ltd., and a group made up of The Superior Oil Company, Pacific Petroleums, Ltd. and others.

Stettler Field

	Year 1949	Jan. to Sept. 1950[1]
Producible Oil Wells	3	20
Oil Production	15,725	118,220
Average Daily Production	201	486
Wells Drilling—Period's End	3	1
Cumulative Production†	15,725	133,945

† From Inception.

Another late arrival in 1949, the Stettler field could develop into a major producing area. Latest allowable rates set in October were 145 barrels daily for each D-2 zone well, and 100 barrels daily for each D-3 well.

Gulf Oil Company, Ltd., discovered the field and presently has 12 wells. The company holds most of the acreage around the present wells and also owns the blank two-mile corridor between the present north and south locations.

Daily production for the field varies, depending upon the ability to move the oil. Daily output for the week ending October 9 was 754[1] barrels; and at the same time the total number of productive wells reached 21. This is another of the several small, new fields which have not had

their productive limits determined, nor their development completed because of lack of oil outlets.

Gulf has two dual-completion wells in the field, which as far as can be determined are the only ones in Canada. The wells tested 4100 barrels per day from the D-3 zone and about 750 barrels per day from the D-2.

Principal leaseholders are Gulf, British Empire Oils, Ltd., and the combine of Can-Tex and Challenger oil companies.

Joseph Lake Field

	Year 1949	Jan. to Sept. 1950[1]
Producible Oil Wells	4	13
Oil Production	35,858	64,855
Average Daily Production	382	267
Wells Drilling—Period's End	1	3
Cumulative Production†	35,858	100,713

† From Inception.

The first to obtain oil production in the Viking Sand formation in Canada, Joseph Lake is just beginning to grow. The field has been getting three to five successful completions a month, until the total productive wells stood at 21 on October 17. Discovered early in 1949, the field has had only one failure in 22 starts.

Daily production was 885 barrels the first of October and had increased to 981[1] barrels by October 9. Per-well allowables set for October were 50 barrels daily, one of the lowest rates in Canada. The low allowable was predicated upon the difficulty of moving the oil to transport centers, and the desire to make a study of the reservoir before too much oil was withdrawn.

At the time 11 successful wells had been completed, an estimate of the recoverable reserves was set at about 7.5 million barrels by J. F. Langston, who has a paper in this section. Undoubtedly, this spot-estimate would be increased materially in view of the latest well completions.

Joseph Lake is enclosed by a 10,630-acre unitized block held jointly by Superior, the operator, General Petroleums of Canada, Ltd., Kroy Oil Company, Ltd., Jupiter Oil Company, Ltd., and Imperial. The companies' share schedule and payout arrangement is described in detail in the Important Fields portion of this section.

Golden Spike Field

	Year 1949	Jan. to Sept. 1950[1]
Producible Oil Wells	2	4
Oil Production	85,081	201,771
Average Daily Production	325	830
Wells Drilling—Period's End	1	1
Cumulative Production†	85,081	286,852

† From Inception.

Golden Spike has the doubtful distinction of being the fifth largest producing field, and the tenth smallest in number of wells in Alberta. The pride of the oil industry when it was discovered last year, the field has turned out to be quite a disappointment in areal extent. Following the completion of three producers in May, Imperial engineers estimated that about 9.7 million barrels of oil would be recovered from the 120 acres proved, figuring 3.24 million barrels per 40-acre tract. On this basis, with four successful producers, the recoverable reserves might be taken to be about 13 million barrels. Imperial has drilled seven wells to get the four producers and the limits of the Devonian reef pool are thought to be established as being quite small.

Reason for the large production from such a small pool is that the average effective pay thickness exceeds 400 feet, and one well alone tested 12,000 barrels per day on potential. The per-well allowable for the field at mid-year was set at 900 barrels daily, which Imperial voluntarily cut to 255 barrels.

Imperial is the only leaseholder in the present field.

Campbell Field

	Year 1949	Jan. to Sept. 1950[1]
Producible Oil Wells	1	6
Oil Production	4,685	33,296
Average Daily Production	21	137
Wells Drilling—Period's End	1	1
Cumulative Production†	4,685	37,981

† From Inception.

While the above are the latest overall statistics on the Campbell field, the number of producing wells, as of October 16 had reached eight and daily production had reached 320 barrels. Discovered in 1949, the field is held in high esteem by the operators, Redwater Leaseholds, Ltd.

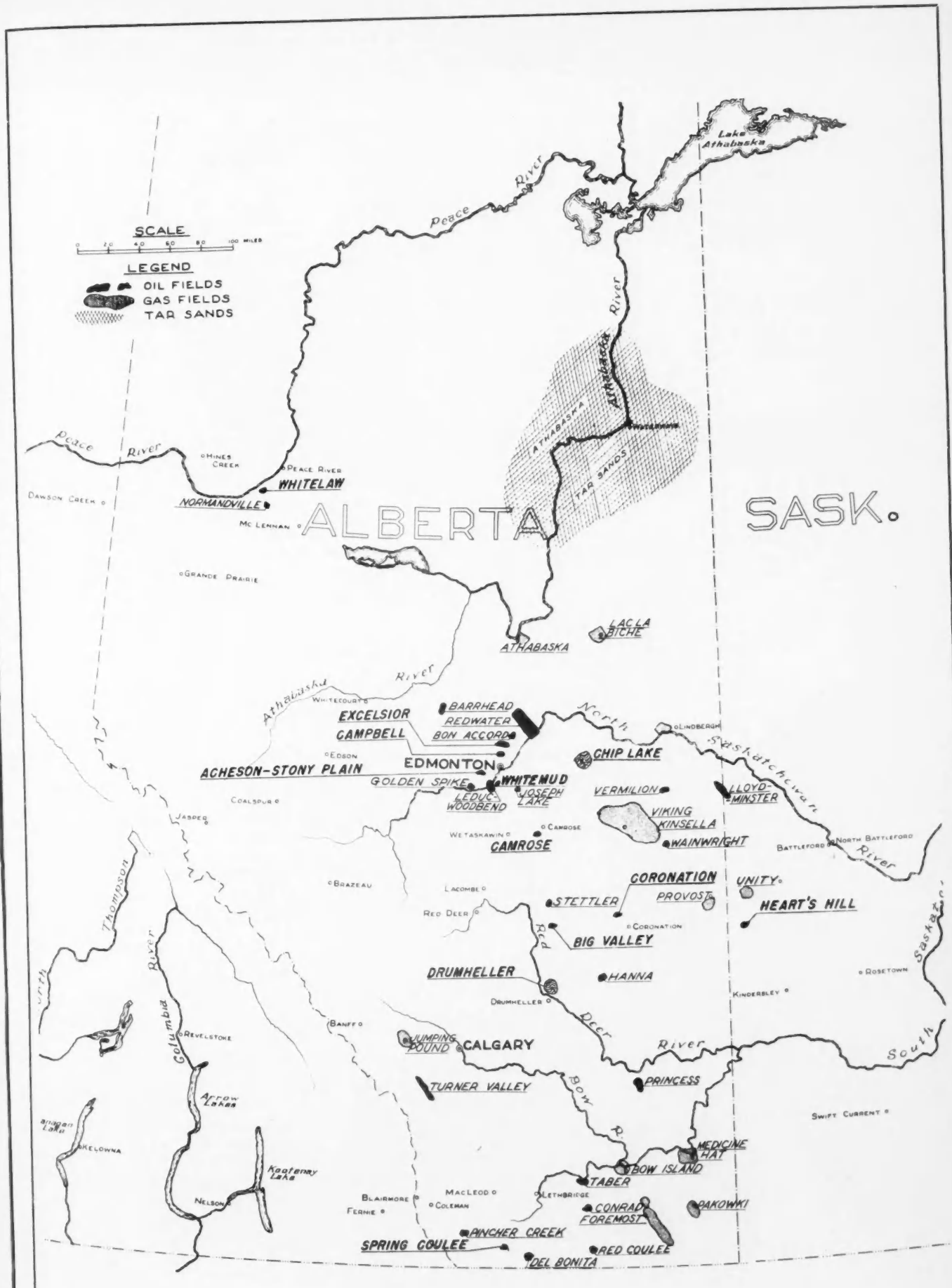
Per-well daily allowable was set at 50 barrels for the field in October. The highest monthly production for the field was 8845 barrels in May, and under its present allowable quota the field could produce 12,000 barrels monthly, if it were possible to move the oil out in that volume.

Whitemud Field

	Year 1949	Jan. to Sept. 1950[1]
Producible Oil Wells	4	5
Oil Production	26,506	32,622
Average Daily Production	157	134
Wells Drilling—Period's End	2	2
Cumulative Production†	26,506	59,128

† From Inception.

Rolling country typical of the area around Camrose, where an oil discovery was made late this year. The highway number will probably be changed in view of the recent success with oil.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0 20 40 60 80 100 MILES
LEGEND
OIL FIELDS
GAS FIELDS
TAR SANDS
Lake Athabaska
Peace River
Athabasca River
ATHABASKA TAR SANDS
ALBERTA
SASK.
Peace River
Hines Creek
Peace River
WHITELAW
Dawson Creek
NORMANDVILLE
Mc Lennan
Grande Prairie
ATHABASKA
LACLA BICHE
Athabasca River
Whitecourt
EXCELSIOR
CAMPBELL
BARRHEAD
REDWATER
BON ACCORD
Edson
ACHESON-STONY PLAIN
EDMONTON
GOLDEN SPIKE
WHITEMUD
LEDUC-WOODBEND
JOSEPH LAKE
Coalspur
Jasper
CHIP LAKE
VERMILION
LLOYDMINSTER
North Saskatchewan River
VIKING KINSELLA
WAINWRIGHT
Battleford
North Battleford
Wetaskawin
Camrose
CAMROSE
Brazeau
Lacombe
Red Deer
CORONATION
PROVOST
STETTLER
UNITY
HEART'S HILL
Coronation
BIG VALLEY
Red Deer River
DRUMHELLER
HANNA
Drumheller
Rosetown
Kinderbley
Saskatchewan River
Thompson River
Columbia River
Revelstoke
Banff
JUMPING POUND
CALGARY
TURNER VALLEY
Bow R.
South Saskatchewan River
PRINCESS
Swift Current
Arrow Lakes
Okanagan Lake
KELOWNA
Kootenay Lake
Nelson
MEDICINE HAT
BOW ISLAND
TABER
MacLeod
Blairmore
Coleman
Fernie
Lethbridge
CONRAD
FOREMOST
OAKOWKI
PINCHER CREEK
SPRING COULEE
RED COULEE
DEL BONITA

Whitemud recently added its sixth producing oil well. Discovered in 1949, the field was shared by Imperial and New Pacalta Oil Company, Ltd. The field has not developed as well as was expected and Bay Petroleum Corporation bought out Imperial's two producers early in the year. Two other companies have since obtained one producing well each. Bay is presently attempting to find more production.

Other fields such as Brooks, Conrad, Normandville, Princess, Taber, Vermilion and Wainwright are not listed because in most cases the production is declining and activity in these fields now is negligible. In the case of the Normandville 1949 discovery, no new wells have been drilled this year and the field is still an unknown quantity. The Volmer 1948 discovery well was abandoned late this year.

Important 1950 Discoveries

Acheson-Stony Plain Field

A field discovered in September of this year is the Acheson-Stony Plain, about eight miles west of Edmonton. Standard Oil Company of California found first D-3 production in Acheson-Province 1 after drilling a dry hole 4½ miles east. The discovery followed three years of intensive seismic and gelogical exploration in an area held jointly by California Standard and Imperial.

Acheson-Province 1 found the top of the D-3 at 4969 feet and had an initial potential of 1219 barrels daily on one-half-inch choke. The discovery was soon followed by Imperial's Stony Plain 1 about four miles southwest of the Acheson but it was not as good a producer. Central Leduc Oils, Ltd. completed Wild 1 September 19, 2½ miles southwest of Acheson 1, finding oil in the Lower Cretaceous sand, the D-2 and D-3 reefs. The latter company then joined with Del Rio Oil Producers, Ltd.—both are independents—and drilled a second well 1½ miles northeast of Acheson 1, finding oil in the Lower Cretaceous. The sand was topped at 3960 feet and made 84 barrels per hour on initial test.

Meanwhile, California Standard and Imperial drilled Welbourne 16-3, a west offset to the Acheson 1 discovery, and found commercial production in the D-2 and D-3 zones. This group was drilling a third well one-fourth mile to the north which was known as the Acheson 1-10.

Central Leduc-Del Rio were drilling their Acheson 1 well 1½ miles northeast of the Acheson discovery and Central Leduc was drilling their Wild 2 and 3 wells near the Wild 1 discovery. To complete the activity, Redwater Picadilly Company was drilling a Stony Plain well 3½ miles southeast of Imperial's Stony discovery.

As the new field now stands it has developed a trend about 5 miles long and 1 mile wide about 5 miles north of the main Leduc-Woodbend field.

Camrose Field

Discovered by Socony-Vacuum Exploration Company in mid-September, the Camrose field is 12 miles southwest of the town of Camrose and and 40 miles southeast of the Leduc-Woodbend field. The company's Flint 1 discovery tested 2078 barrels per day from the D-2 zone and 1110 barrels per day from the D-3. The company followed up about 2½ miles northeast with Camrose 28-1, which found oil production but no tests were given. A third well, Ramsay 15-13, was drilling about two miles east of the Flint 1 discovery. The field is too new to permit an estimate of its possible potential.

Big Valley Field

Another mid-September discovery was Canadian Gulf Oil Company's Big Valley 7 well about 80 miles northeast of Calgary and 17 miles south of Gulf's Stettler field. The well got an estimated initial potential of 2160 barrels per day from the D-2 zone and about 972 barrels per day from the D-3 zone. Big Valley is notable for being the most southerly discovery of D-3 oil production to date.

Gulf has followed up its discovery by starting Big Valley 9 about one-half mile northeast and Big Valley 3 about one-half mile southwest of Big Valley 7.

Whitelaw Field

Located north of the deep valley of the Peace River, 35 miles northwest of the 1949 Normandville discovery, the Whitelaw field may develop into an important producer in Alberta's far northwest. Drilled jointly by Shell Oil Company and British American Oil Company, the discovery well tested gas in the Triassic sand at 3298-550 feet and 640 barrels of oil per day from the Pennsylvanian at about 3815 feet.

The present well is awaiting production equipment and development

Pollard Photo

Pipe lines are building in Canada as fast as material is available and permits can be obtained.

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of the area is expected to continue.

Other Late Discoveries

In addition to the above fields which have provided encouraging results are recent discoveries in the Bulwark-Coronation, Ellerslie and Chip Lake areas.

A team consisting of Canadian Fina Oil Company, Sun Oil Company, Husky and Phillips Petroleum Company have completed two wells in the area between the towns of Bulwark and Coronation, about 50 miles east of Stettler. The first well, Fina-Bulwark 1, found Viking sand production of about 25 barrels daily, five miles northwest of Bulwark, and was being pumped. The second well, Fina-Young Creek 1, about 4½ miles southeast of the discovery had not reported final results.

Four miles south of Edmonton, near Ellerslie, Pacific Petroleums Limited and a group of independents completed P-R-C Ellerslie 1 in the Lower Cretaceous sand at about 3907 feet. The well has not yet been evaluated but on a drill-stem test light crude oil flowed to the surface 11 minutes after the testing tool was opened.

At Chip Lake, about 55 miles east of Edmonton, a wet gas well was found in October which tested 820,000 cubic feet of gas and 13 barrels of high gravity oil, plus about 35 barrels of gas derivatives daily. Further drilling is planned in this area to determine the extent of the gas or oil source. Select Oils Limited, an independent, is the operator in the new area.

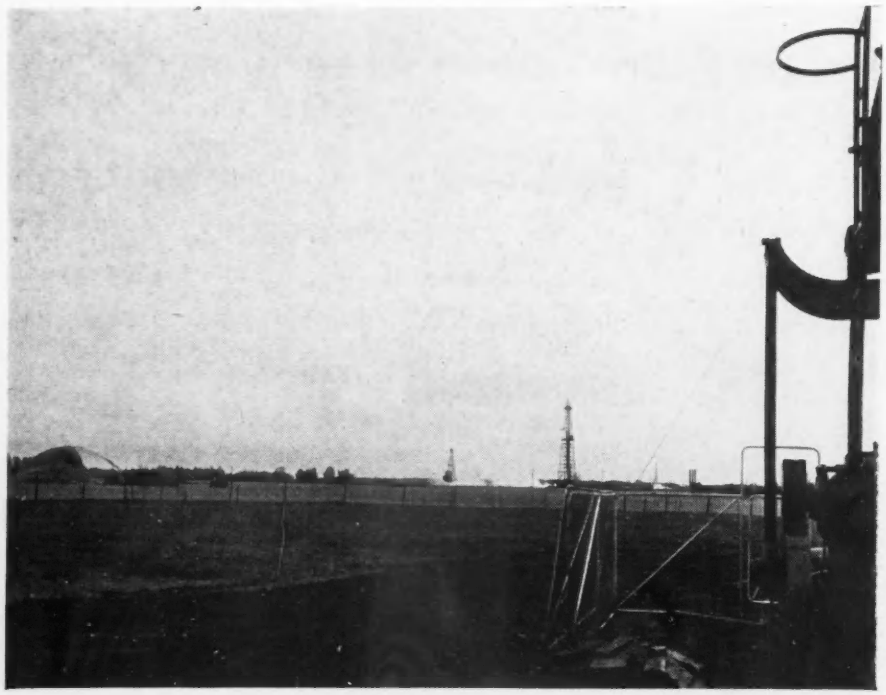
An area of interest late this year was the Spring Coulee field, 140 miles south of Calgary. The field was discovered in 1935 but was never developed into a truly productive area, although the four original wells in the field are reported to have produced about 60,000 barrels in the past 15 years. Recently activity has been renewed in the area and four wells were being drilled. Production was sought from the Madison lime, which has produced over 50 million barrels just 50 miles across the border in Montana. National Petroleum Corporation Limited and Centennial Oils Limited, affiliated companies, are presently active in the area. National-Malmburg 1, four miles north of the main field, started the new boom and National-Centennial 1, recently completed near the old wells, is reported to be producing 100 barrels daily from the Madison lime on pump. The same companies took over an earlier well, Calvan Tower-Spring Coulee 1, three miles north of the main field, and deepened it to the Madison. Production was reported in this well after the Madison was topped at 5999 feet. Halfway between the Malmburg and Centennial wells the National-Malmburg 2 was reported producing 80 barrels daily from the Madison.

Gas Reserves

At the American Association of Petroleum Geologists' meeting in Banff, Alberta, in September, Dr. George S. Hume, director of scientific services, Canadian Department of Mines and Technical Surveys, said that the prairie provinces' gas reserves are now about 7 trillion cubic feet. He stated that in the past 19 months the gas reserves had increased over 2 trillion cubic feet, not counting single well gas discoveries throughout the prairie area, which includes Alberta and Saskatchewan. It is notable that the present gas reserves were discovered while drilling for oil and no actual campaign has yet gotten under way to develop gas supplies alone. This is better illustrated by enumerating the locations and amounts of the present known reserves; for example, Pincher Creek has 1580 billion cubic feet; Leduc 943 billion in the D-3, 163 billion in the D-2 and probably 155 billion in the Lower Cretaceous; Viking-Kinsella 1116 billion; Jumping Pound 942 billion; Pendant - D'Oreille 291 billion; Princess 425 billion; Legal-Morinville 234 billion; Viking 33 billion; Medicine Hat probably 342 billion; Turner Valley 251 billion; Redwater 96 billion; Provost 57 billion; Pouce Coupe 48 billion; Manyberries 34 billion; Black Butte and Pinhorn 42 billion; and Golden Spike about 25 billion cubic feet.

In addition to these known sources of gas, additional discoveries are being made regularly throughout Alberta. Near the town of Drumheller, about 60 miles northeast of Calgary, Naco Petroleums Limited found a potential gas field with Naco 1 which tested 10 million cubic feet per day. Producing from the Basal Cretaceous sands, the first well is being followed up with Naco 2 about four miles to the west.

Imperial discovered a gas field at Round Hill, about 19 miles southeast of the Joseph Lake field, with Round Hill 1. The well tested a little more than 1 million cubic feet daily from 3472 feet and the well is being carried down to test lower zones. Cessford, about 100 miles east of Calgary, is another potential gas area being developed by Canadian Delhi Oil Corporation. Cessford 1 tested 3.5 million cubic feet daily from the Basal Cretaceous topped at 3393 feet. Cessford 2, about eight miles southeast of the discovery, tested 2.5 million cubic feet daily from the same sand topped at 2914 feet. Cessford 3 has been started 2½ miles southeast of Cessford 2 and the company plans to develop the field as quickly as possible.



South end of Leduc field showing an Imperial Oil Limited well pumping in the foreground and three rigs drilling in background. Farmers are threshing wheat to the left, unmindful of the oil activity in the vicinity.

Other Western Provinces

Ten active drilling rigs are presently operating in Saskatchewan in an effort to bring that province into

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Turner Valley looking toward the Rocky Mountains to the west. The field is on the decline and only two to three rigs are currently operating.

the oil picture. Two of these rigs are on development drilling in the Lloydminster field and eight are exploratory rigs. The exploratory rigs are operating from Maple Creek, 60 miles north of Montana to Birch Lake, due east of Edmonton. In addition to this 500-mile span of exploration by private companies the government is drilling tests in the northwest corner of the province to correlate subsurface data there with the information being assembled to the south. Three tests were drilled this summer to about 2300 feet near the town of Big River, 90 miles northwest of Prince Albert. The government intends to continue this shallow drilling in areas where private companies are not operating.

Aside from the Albercan Heart's Hill discovery, near Kerrobert in west central Saskatchewan, no outstanding oil discoveries have been made in the province this year. Interest is presently centered about St. Walburg, 50 miles northeast of Lloydminster, where a group of independents have reached the drilling stage of an exploration program to cover 500,000 acres. After intensive geological and geophysical prospecting and several test holes, the group has spudded its St. Walburg 1 northwest of Brightsand Lake.

In Manitoba, drilling activity is presently confined to one rig in the Souris River valley, a few miles north of the Montana border. A third wildcat is presently getting under way there after two dry holes by an independent operator.

About 50 oil companies are presently active in British Columbia, exploring for oil and building refinery and pipe line facilities. Exploration for oil and gas is chiefly confined to surface reconnaissance in six different regions of the province, although two wells are now being drilled near Lone Mountain and New Westminster. The 90,000-square-mile region of sedimentary deposits in the Peace River section of northeast British Columbia is undergoing intensive geophysical work, and the Lone Mountain well will furnish additional data on the area. The well is expected to be carried to 12,000 feet regardless of anything found at shallower depths. Much of the Lone Mountain region is characterized by gas seeps on the surface, and Phillips is drilling the present well near one of the larger seeps.

The New Westminster well is going down in the Fraser Valley area near Vancouver, an area which has been thoroughly leased. The Queen Charlotte Islands between Vancouver Island and the mainland are also undergoing intensive geological exploration. The Flathead River area, in southeast British Columbia, just above the Glacier National Park, has attracted exploration parties because of numerous gas seeps in the area plus the fact that it may be a continuation of the Pincher Creek gas field in Alberta. British Columbia is generally encouraging oil exploration by softened regulations governing leasing and development.

Western Canada Wildcat Drilling

Total number of wildcat rigs in operation in Western Canada reached 61 late this year. Of these, one was in Manitoba and eight were in Saskatchewan. Wildcatting in Alberta is currently moving from the northern section into the plains between Edmonton and the Montana border; however, eight rigs are still running in the Peace River area where the Normandville 1949 and the Whitelaw 1950 discoveries are located. Twenty-four wildcats were operating near and around Edmonton in an effort to find more fields of the Redwater-Leduc caliber, making Edmonton the most active wildcatting center at the present time. From Big Valley to Camrose seven or eight rigs were operating to determine the trend of these 1950 discoveries and the remainder of the rigs were operating in the southeast plains and in the area south of Lethbridge, near the Montana bor-

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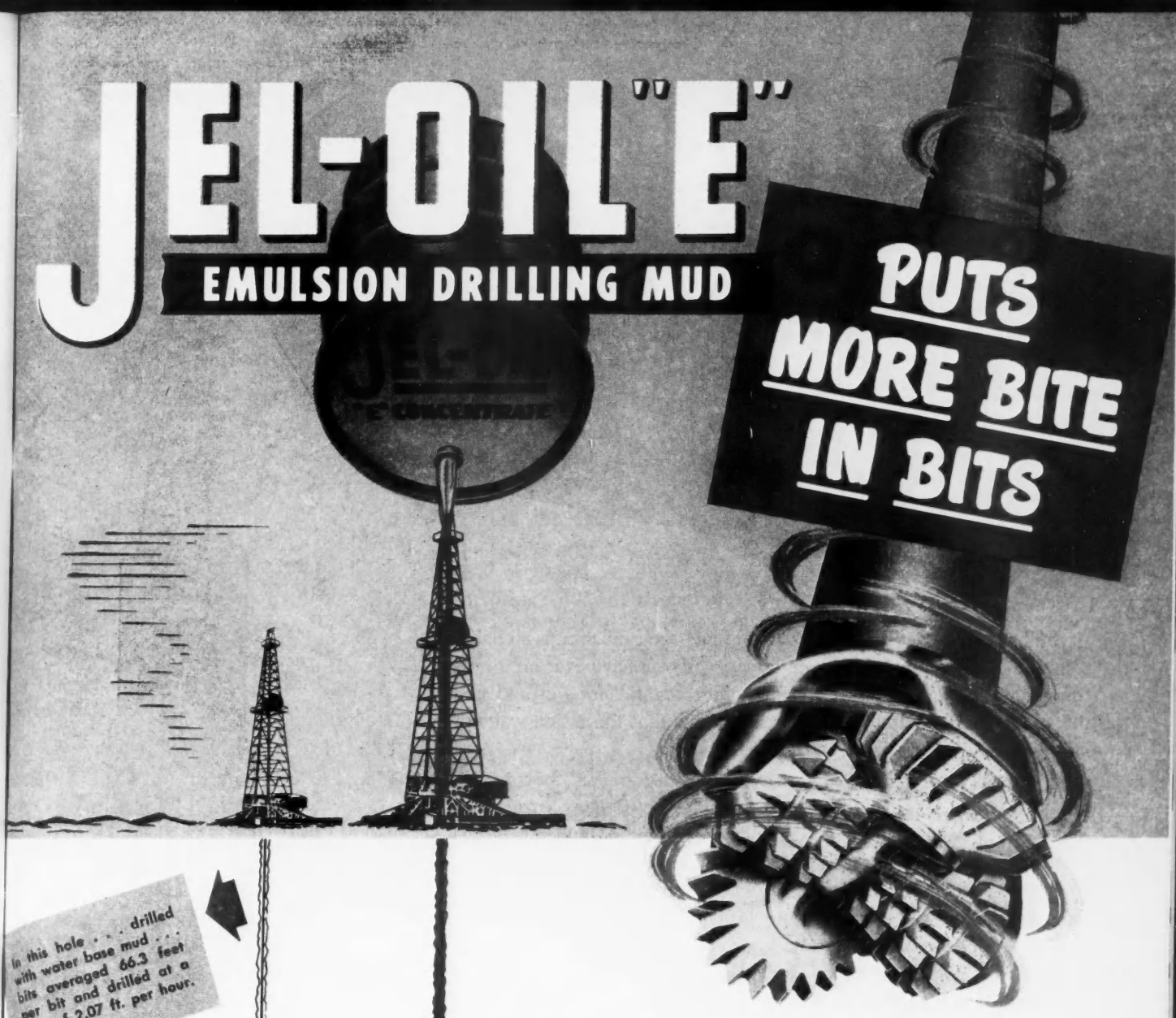
In this hole . . . drilled with water base mud . . . bits averaged 66.3 feet per bit and drilled at a rate of 2.07 ft. per hour.
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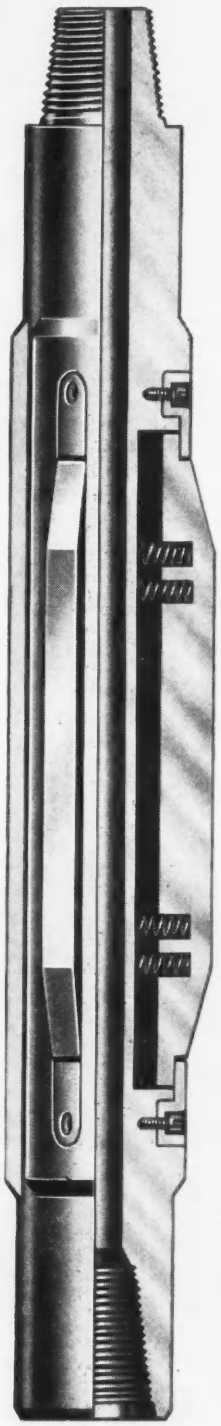
The field-tested Baker MODEL "B" Casing Scraper (Product No. 620-B) is recommended for use when the rotary rig still is up and only hardened cement or a limited number of gun-shot burrs are to be removed. It is usually run just above the bit while drilling out cement, and will remove protruding burrs as well as the thin sheath of cement left even after the maximum gauge bit has been used for drilling out.

When there are several hundred gun-shot holes (with possible imbedded bullets); or if the hardened sheath of mud is to be removed from top to bottom of the well, the new Baker ROTO-VERT Casing Scraper (Product No. 620-C) is recommended. The ROTO-VERT can be run on drill pipe for successful vertical scraping of obstructions as it is being lowered in the hole, followed by rotation if difficult well conditions make rotation necessary or desirable; or it is run on tubing or a wire line for successful all-vertical scraping.

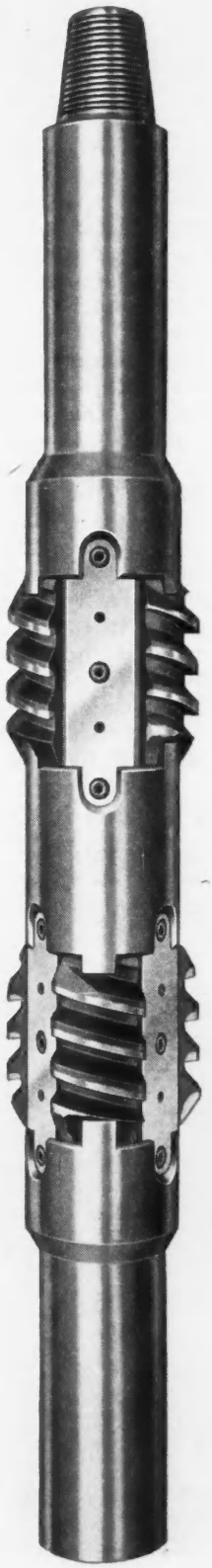
SCRAPING IS A VITAL PART OF WELL COMPLETION

Many operators consider that the use of a Baker Casing Scraper is a "must" in the completion of *every* new well, and after *every* gun-perforating job. They *know* that the inside wall of the casing is left smooth and "clean as a hound's tooth" ready to run a swab or testing



Baker MODEL "B" Casing Scraper
Product No. 620-B

tool with no trouble. They *know* that the tubing or liner can be run easily and safely, and that packers and cement retainers will run-in readily and seal-off perfectly against the clean, smooth inner surface of the casing. Not only is the well then ready for immediate completion, but it will be left with the "working surface" safe for all future down-hole work. Isn't the reasonable rental charge for a Baker Casing Scraper cheap insurance for leaving your well in perfect condition?



Baker ROTO-VERT Casing Scraper
Product No. 620-C

THE NEW BAKER ROTO-VERT SCRAPER IS POSITIVE AND SAFE

The strong, simple construction of this efficient scraper is evident from the illustration which shows the rugged body on which six blade blocks are mounted, and held in position by blade block retainers. These blade blocks are set in two horizontal rows in a staggered position so that the blades overlap and will scrape the full 360° surface of the inner wall of the casing. The scraper blades are cut on a helix angle and provide a scraping, or shearing, action both while moving down the hole and while rotating. The thrust of each blade block, when rotating, is taken by a driving block which is welded to the body. Springs behind each blade block hold the hard-faced scraper blades against the inner wall of the casing where they exert positive shearing action. ROTO-VERT blade blocks will never screw down past a casing burr because their scraping edges follow the contour of a LEFT-HAND SCREW.

Field reports on the ROTO-VERT Casing Scraper prove its efficiency when used as recommended for the removal of a large number of burrs from gun-shot holes, and possible bullets imbedded in the casing. A ROTO-VERT used on two consecutive jobs scraped a total of 1,548 perforation burrs WITH THE SAME SET OF BLADE BLOCKS, and the blades were still in usable condition. Further proof of the complete, clean removal of burrs was provided when the swab cups used in connection with washing the perforations in both wells, were found upon removal from the well, to be in good condition.

You'll always be glad you scraped the "working surface" of your casing

Descriptive literature is available on both types of Baker Casing Scrapers—or, better yet, ask the Baker representative in your area how you profit when you use a Baker Casing Scraper to "KEEP IT CLEAN."

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der. From January to mid-September, 105 wildcats had been drilled in Western Canada, not counting the successful oil and gas discoveries.

Rank wildcats of interest in Alberta late in the year were Pacific Petroleum Company's Driftpile 1, south of Lesser Slave Lake and about 200 miles northwest of Edmonton; Home Oil Company's Nordegg 1, 30 miles northwest of Nordegg and 180 miles southwest of Edmonton; and the Ram River location, 20 miles west of Rocy Mountain House and 160 miles southwest of Edmonton. Driftpile 1 is to test 250,000 acres of leases held by Pacific, and the Ram River well will test 80,000 acres held by a New York group of businessmen, recently incorporated into the Plateau Petroleum Limited.

Pipe Line Operations

Aside from the Interprovincial Pipe Line, described elsewhere in this issue, Canada has several other pipe line outlets under construction or in the planning stage. Adequate, low-cost transportation for western oil and gas has been one of the large factors holding back more rapid development of Canada's newest and most important resource.

In October a ten-inch, 75-mile pipe line was completed from Winnipeg to Gretna, Manitoba, which will supply the former city's refinery with about 30,000 barrels of crude daily from the Interprovincial Pipe Line carrying oil from Alberta to the Great Lakes. The same month a six-inch, 21-mile line was completed from Moose Jaw, Saskatchewan to the Interprovincial line. These two lines are the beginning of a pipe line grid system to the major cities in Western and Central Canada to be supplied from the large transcontinental line.

Application has been made by Canadian Delhi Oil Limited to build a gas pipe line from Alberta 2132 miles east to Montreal, serving all the larger Canadian cities in between. The line as it is now proposed would cost about $220 million. Prairie Pipe Lines Limited has also filed an application for permission to build a 170-mile gas line from the Pincher Creek field in Alberta to Kingsgate, British Columbia, where it would join the Pacific Northwest Pipe Line supplying Vancouver and Western Canada's coast towns. The same company proposed that it build a 580-mile gas line from Windsor, Ontario, to Montreal. To feed this line a 1000-mile transmission line would be built from Oklahoma to Windsor.

An oil pipe line from Alberta to Spokane is expected to come into being. While such a line is still in the talking stage, it is the consensus that the line will be built as soon as the Interprovincial line is fully operating and a surplus again builds up in Alberta. At the rate Alberta fields are developing, the Interprovincial pipe line was outdated before it was completed.

On a smaller scale, but of immense interest to Calgary, is the 27-mile, 12-inch gas line being built from the Jumping Pound field to that city. The city needs the gas and the outlet will permit further development of the field, which has been shut in since its discovery in 1944. Built at a cost of $750,000, the line will deliver up to 20 million cubic feet daily. Following completion of this short line, another gas line may be built from Jumping Pound to Banff to the west.

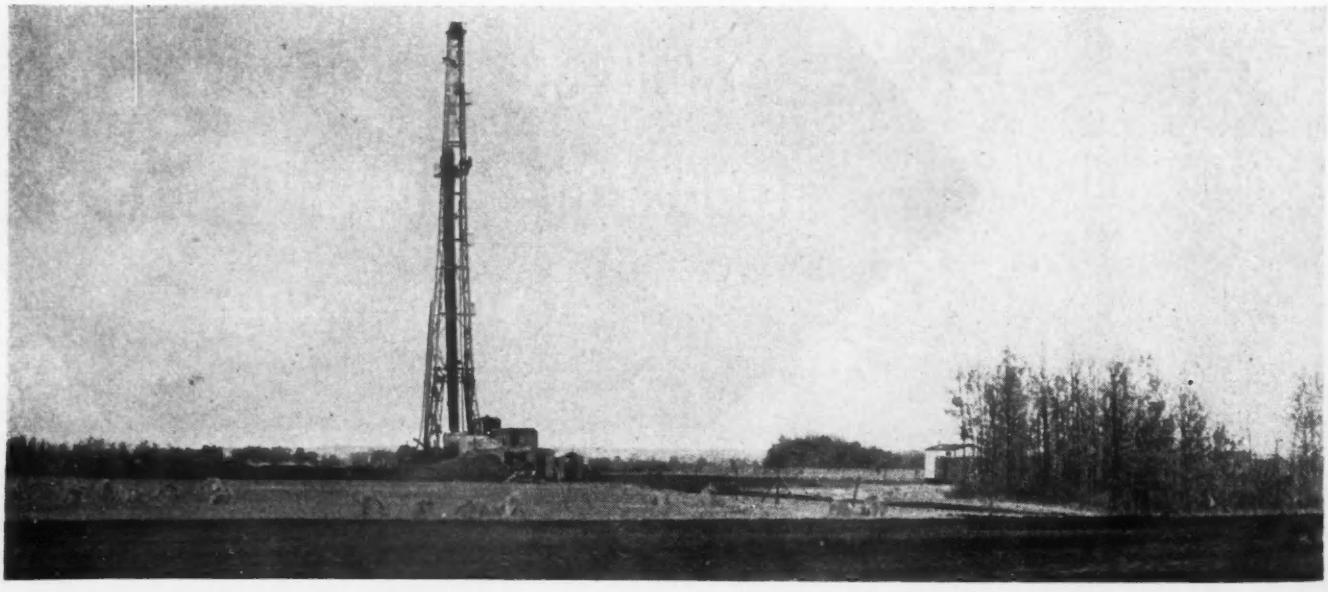
Canada's Refineries

Canada ranks second in number of refineris in the world, having 39 plants compared with 351 in the U. S., 30 in Western Germany, 18 in Argentina, 17 in Japan, and 16 in the United Kingdom. While second in number, Canada rates fourth in capacity with about 283,000 barrels daily. The explanation for this is that Canada has small plants scattered throughout the Dominion while most of the other countries have just a few large-capacity plants. Expansion of refining facilities near the source of the oil in Canada is assuming increasing importance and a $30 million program is presently under way to build new plants and enlarge the existing ones in the prairie provinces, particularly around Edmonton, Regina, Calgary and Lloydminster. With the completion of Interprovincial Pipe Line, Eastern Canada also will have increased refinery capacity. Part of this increase will be supplied by a $18 million plant at Froomfield, Ontario, now building. The plant will have a yearly capacity of 5 million barrels when completed in April 1952. The present refinery at Petrolia, with a 3500-barrel daily capacity, will switch to Canadian crude from the Interprovincial Pipe Line when deliveries to Ontario commence in the spring. This will reduce U. S. imports by $3,500,000, and when the larger refinery is completed the reduction will amount to $17,500,000.

REFERENCES

[1] The Alberta Petroleum and Natural Gas Conservation Board.

[2] *The Daily Oil Bulletin*, Calgary.



Portable rig drilling in Whitemud field ten miles south of Edmonton.

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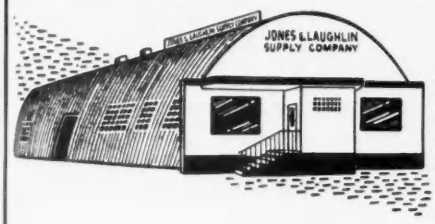

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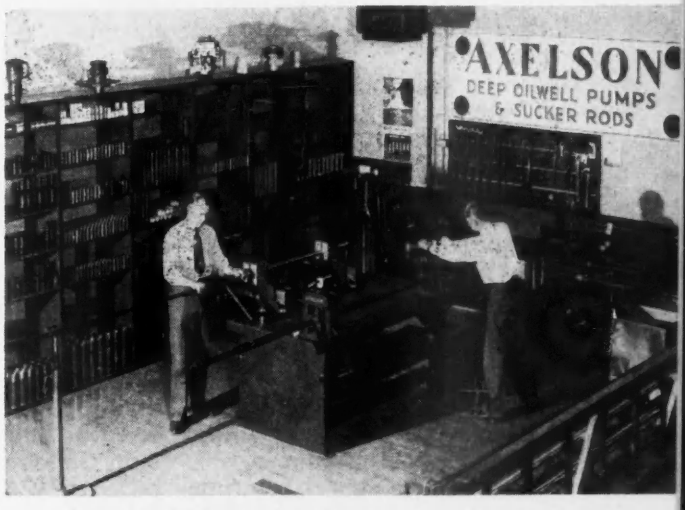

Pump Repair Shop in the Edmonton Store. Demonstrating the skillful overhauling of a sub-surface pump: Left to right, H. C. King, Senior Field Salesman and Joseph J. Crawford, Store Manager.

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REDWATER FIELD

Is Canada's Largest Producer

THE Redwater field, 25 miles northeast of Edmonton, is currently Canada's largest field in terms of wells completed, daily production, and proven reserves. Producing from the D-3 Devonian limestone reef which proved so prolific in the Leduc-Woodbend field, the Redwater field was discovered in September, 1948, and has developed into a productive area 15 miles long and four miles wide.

The outer limits of the field have not yet been established and 23 drilling rigs are finding further extensions of production. With productive acreage now exceeding 26,000, the proven reserves of Redwater are calculated to be about 500 million barrels. It was conservatively estimated in October that the field has only been about 50 percent drilled up. The D-3 reef as it has developed in Redwater has a net effective pay thickness of 200 feet.

● PRODUCTION DATA: As new as the Redwater field is, it is difficult to estimate the probable ultimate production that will be obtained, but the operators are confident that the field will exceed anything yet found in the prairie provinces. Recoveries are expected to be on the order of 20,000 barrels per acre.

The D-3 limestone reef in the Redwater field is found at 3200 feet and the wells are bottomed about 20 feet lower. To date, 674 producing wells have been completed in the field. Typical wells have potentials of 1400 barrels daily, but the current allowables are set at 165 barrels daily. While the wells generally are brought in flowing, some are now on pump and more are expected to be pumped as the low pressure gas in the reservoir dissipates. The field follows a 40-acre spacing rule and the crude is about 35 gravity. Original bottom-hole pressure was 1050 pounds per square inch and the gas-oil ratios of the wells average about 400 cubic feet per barrel. Oil is now moved from the field by pipe line to the head of the Interprovincial Pipe Line in Edmonton.

The discovery well, Imperial Oil Limited's Redwater 1, found light oil in the D-3 at 3200 feet and tested 1400 barrels daily from the Devonian.

● DRILLING DATA: With 23 rigs running in the field, Redwater is second to the Leduc-Woodbend field in that category and the work is all classed as development. Wildcatting is being done some distance from the field but no stepout drilling is being done about the field proper.

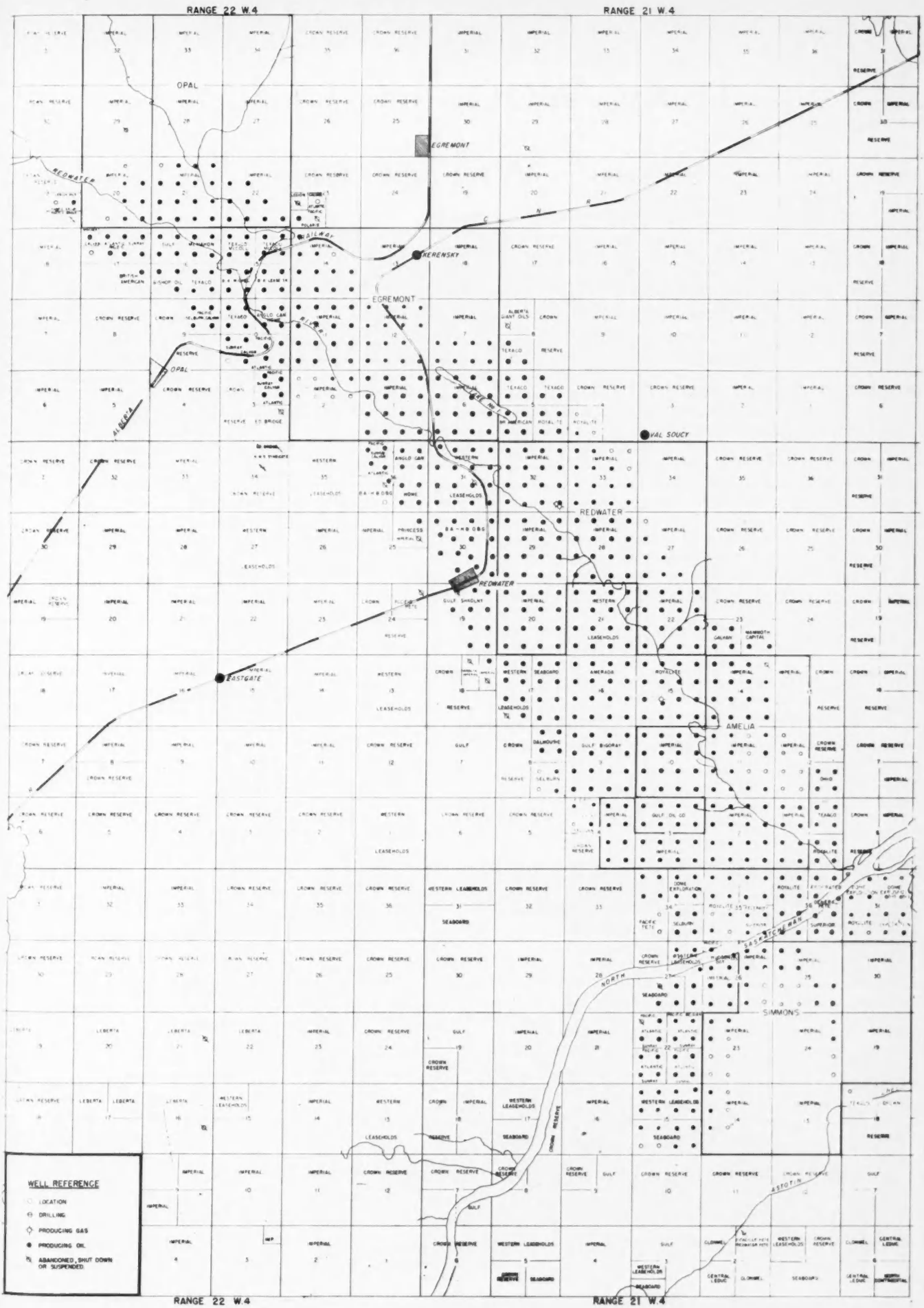
Typical casing programs call for 10¾-inch set between 400 and 600 feet with 200 sacks and seven-inch oil string set on top of the D-3 reef with 500 sacks. Completions are open hole as a rule, although liners are sometimes set through the pay zone and perforated. Acid is frequently used in small amounts to open up the face of the hole. Seven to 10 nine-inch bits are used per well.

Drilling mud programs are uniform between operators due to the fact that unusual drilling problems do not occur. Lost circulation in the vuggy limestone section above the D-3 present some difficulty but the volumes of mud lost usually are not great. Gel-type mud is used as a general rule and lost circulation is corrected with any materials on hand such as shredded mud sacks, wheat straw and so on. However, some of the operators are turning to fibrous lost-circulation material and other commercial preparations for this purpose with marked success. Other operators set cement plugs in zones where abnormal mud losses occur.

Average drilling time in the Redwater field is about five to seven days with tear-down and rig-up time amounting to one or two days with the portable derricks now being used. Where conventional, medium-size derricks are used, the derricks are skidded from one location to another when possible, and moving time is cut to a minimum. The rigs are either gas or diesel driven and two medium-size mud pumps are used with one shale shaker. Excavated pits and steel mud tanks are used in about equal proportion. Water is obtained from shallow water wells and nearby creeks.

Prevailing footage rates in Redwater are from $4 to $4.50 per foot; daily rates run from $550 without drill pipe to $650 with drill pipe. A fully equipped well costs about $50,000.

The town of Redwater is practically a supply town, and the stores and service companies not represented there have facilities in Edmonton, 25 miles southwest. Field roads are gravel and dirt and are usually passable unless extremely wet. The road out of Edmonton to the field is paved about halfway and gravel the remainder. The surface terrain is predominantly flat farm land, broken by numerous groves of trees. Living accommodations are good in Edmonton, but most of the crews live in Redwater and other small towns in the vicinity.


RANGE 22 W.4
RANGE 21 W.4
OPAL
EGREMONT
REDWATER
KERENSKY
VAL SOUCY
EASTGATE
AMELIA
SIMMONS
ASTOTIN
NORTH SASKATCHEWAN RIVER
WELL REFERENCE
LOCATION
DRILLING
PRODUCING GAS
PRODUCING OIL
ABANDONED, SHUT DOWN OR SUSPENDED
RANGE 22 W.4
RANGE 21 W.4

IMPORTANT Canadian FIELDS

LEDUC-WOODBEND FIELD

Was First Major Find in Area

LOCATED 18 miles southwest of Edmonton, the Leduc-Woodbend field was instrumental in starting the large wave of exploratory activity in 1947 that resulted in such prolific fields as the Redwater, Excelsior, Stettler and Joseph Lake. It was in this field that D-3 reef production was finally established after years of near-misses throughout the province of Alberta. Producing from the Lower Cretaceous sand, the D-2 and D-3 limestone reefs, the Leduc-Woodbend field currently approaches the Redwater field in daily production Although it has about 200 fewer producing wells, Leduc has equal pipe line volume outlet.

After holding the Canadian oil spotlight from its discovery in February, 1947, until Redwater forged ahead this year, Leduc is still a source of intense interest to oil men. The outer limits of the field have not yet been definitely developed, and it appears that it will be some time before the field is completely outlined. Proof of this is provided by the fact that 33 drilling rigs are now operating in the field.

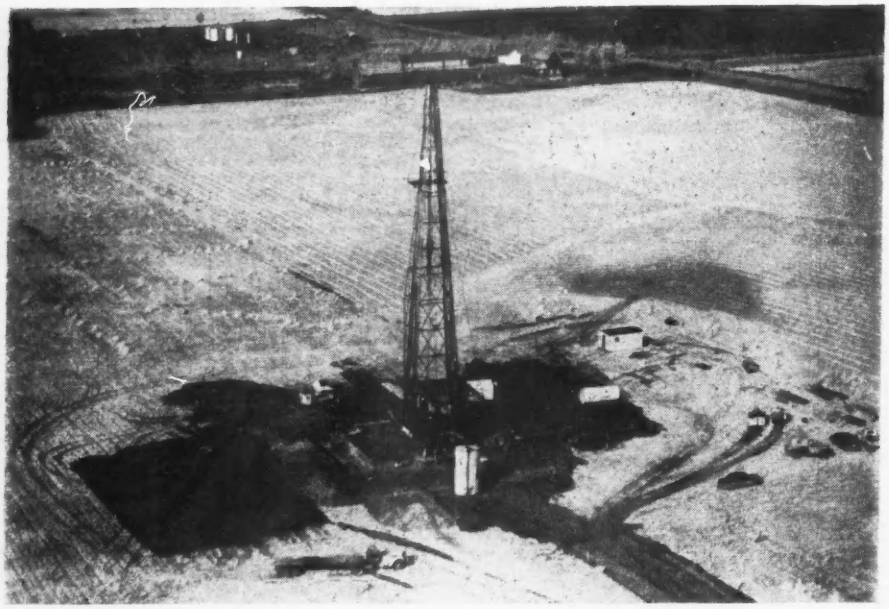
The Leduc-Woodbend field finds substantial production from three formations—the Lower Cretaceous sand, a stratigraphic trap in the Woodbend area, now produces about 11,000 barrels monthly; the D-2 Devonian limestone reef produces about 300,000 barrels monthly; and the D-3 Devonian limestone reef produces about 1.1 million barrels monthly. The configuration of the D-3 reef governs the relief of the D-2 and Lower Cretaceous zones which lie above it. Following the buildup of the D-3 initially, erosion took place at the top of the reef which segregated sections of the main oil zone, and the contours of the D-3 are reflected above, causing highs and lows which effect the production of the wells completed in the D-2 and Lower Cretaceous.

● PRODUCTION DATA: The field was discovered in February, 1947, when Imperial Oil Company Limited drilled Leduc 1 and found oil in the D-2 reef, topped at about 5040 feet. The D-2 averages 150 feet in thickness and is presently calculated to be about 50 percent drilled. In cases where the wells are drilled down to the D-3 reef, completions in the D-2 are through perforated casing. The net effective pay section of the D-2 averages about 25 feet and the productive area now is about 18.000 acres from which about 47 million barrels of oil will be recovered. The Lower Cretaceous sand, being oil productive in only 13 wells, will give up about 6 million barrels of oil in its present area of about 550 acres. The more productive D-3 reef will record about 200 million barrels from its 23,000 acres.

The D-3 reef was discovered by Imperial's Leduc 2 which topped the formation at about 5200 feet. There are now 173 wells in the D-2 and 294 in the D-3. Where production is found in the D-3, casing is set on top of the section and the well produced through open hole, or a liner is set through the section and perforated. Typical potentials of the Leduc wells range from 250 to 1800 barrels daily, with the variations in either the D-2 or D-3 caused by changes in porosity and pay thickness. Latest allowables for the Leduc field are 40 barrels for the Lower Cretaceous sand, 70 barrels for the D-2 reef, and 110 barrels for the D-3. Twenty-two wells in the D-2 are on pump, while most of the D-3 wells flow. Wells are on a 40-acre spacing pattern for each zone. The gravity of the oil is 39 for the D-2 and 36 for the D-3 zone.

Initial bottom-hole pressures were about 1760 and 1890 pounds per square inch for the D-2 and D-3, respectively. The flowing D-2 wells have a gas-oil ratio of about 450 cubic feet per barrel while the D-3 wells have a gas-oil ratio of about 550. Oil is moved out of the field by pipe line to Edmonton, where it will enter the Interprovincial Pipe Line or go to local refineries.

● DRILLING DATA: The 33 rigs running in the Leduc-Woodbend field



Well drilling in Leduc-Woodbend field which is a well settled and prosperous farming area.

are on development drilling, while four rigs are operating outside the present limits of the field trying to extend the known production. In connection with this stepout drilling, Imperial's Leduc 280, completed in mid-October, has developed a D-3 extension or a separate pool in the midst of D-2 wells in the southwest portion of the field. Arrow on field map indicates the well's position. Leduc 280 topped the D-3 at 5390 feet, about five feet above the main field's oil-water contact, and drilled to 5403 before finding water. Northern Development Company completed P.D. 1 a mile to the west in the D-3, topping the pay at 5396 and completing at 5420 feet without finding water. To confuse the picture of the south end of the field more fully, Texaco Exploration Company completed South Calmar 1 as a D-3 producer, possibly indicating three separate D-3 pools in the area. Located two miles south of the main Leduc field (see double arrow) South Calmar 1 topped the D-3 zone 140 feet below the oil-water contact of the main field.

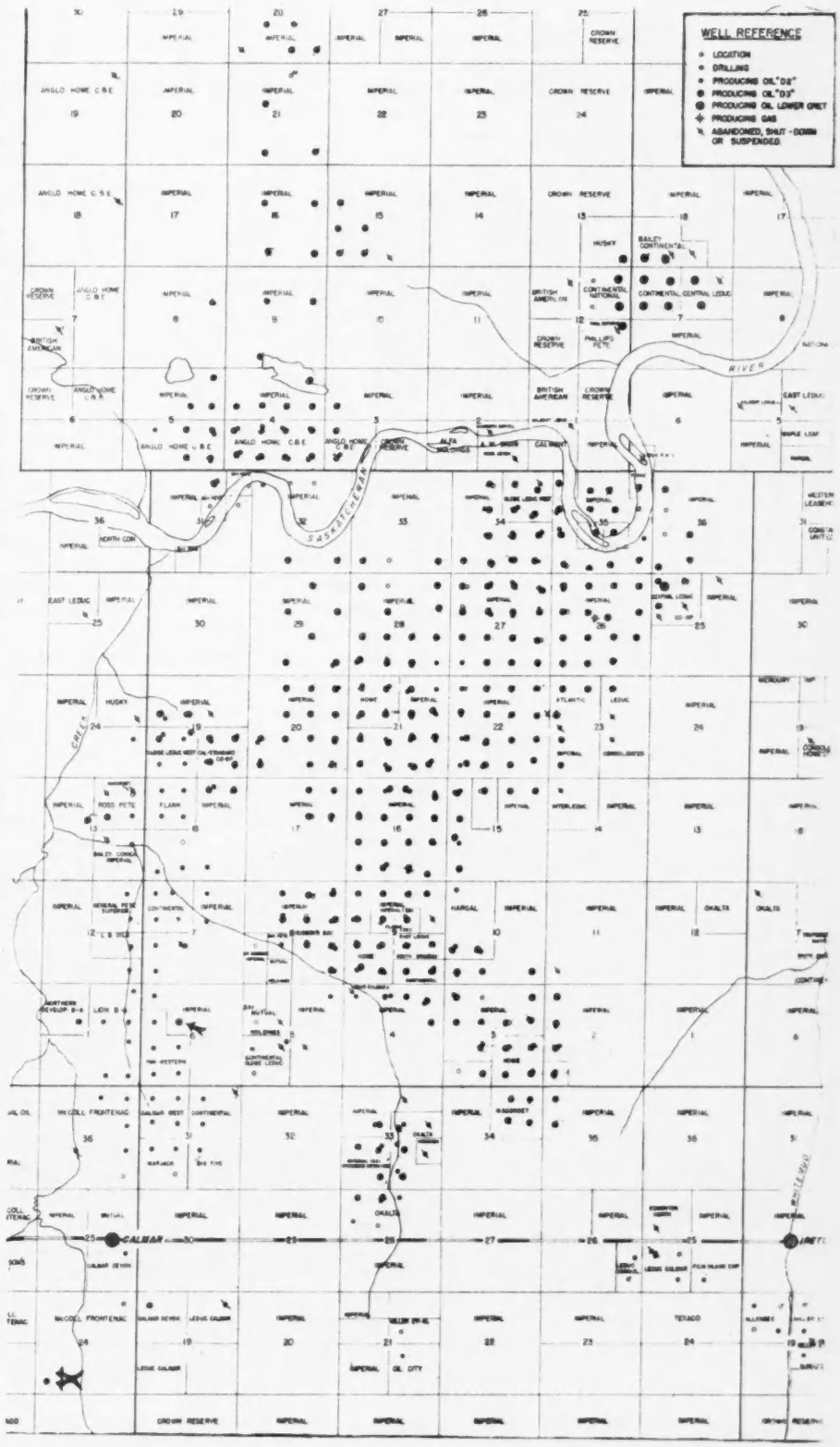
Typical casing programs call for about 400 feet of 10¾-inch surface casing cemented to the surface. A D-2 well has its 5½- or 7-inch casing set on top of the pay with 300 sacks of cement and an open hole or liner completion made. Where D-3 production occurs, the same procedure is followed by casing through the D-2 zone, which can be produced later through perforations. In the Lower Cretaceous wells the casing is set through the sand and perforated. Wash shots of acid are normally used on the D-2 and D-3 zones in amounts from 100 to 1500 gallons to open up the well face. Normally, 20 to 30 nine-inch bits are used per well.

No definite mud programs are normally followed. As a rule gel type mud is used and where lost circulation occurs in the D-2 or D-3 sections any kind of bulky or fibrous material on hand is used to recover returns. In extreme cases, cement plugs are set in the thief zones.

Average drilling time for a D-2 well is about 35 days, and for a D-3 well, about 40 days. Portable and medium-size conventional derricks are used in about equal proportion. Rigs are gas, steam, or diesel driven. Two medium-size mud pumps are used with one shale shaker. Excavated mud pits are used normally, but some of the unitized rigs have steel mud tanks. Gas is available from the field wells and diesel fuel is trucked to the field from nearby Leduc. Water is obtained from shallow water wells and nearby creeks.

Prevailing footage rates in Leduc are $5.50 to $6 per foot; daily rates run from $600 to $650 without and with drill pipe, respectively. A fully equipped well costs about $75,000.

Leduc, about five miles east of the field, has some supply houses, but the bulk of them are located in Edmonton, 18 miles distant by road. Field roads are gravel and dirt, both becoming slippery and soft when wet. A heavy rain will close the dirt roads and make the gravel roads nearly impassable. Some workers live on nearby farms, but the majority drive to and from Edmonton.



IMPORTANT *Canadian* FIELDS

EXCELSIOR FIELD

Has High Potential Development

AN important 1949 discovery, Excelsior field is 18 miles north of Edmonton along the main road leading to the Redwater field. With 22 producers in the D-2 limestone reef formation, the field was instrumental in creating interest in the D-2 section north of Leduc.

It will be noted on the map that the field proper has possibilities of development in a north-south direction, with a blank three-fourths mile corridor in the middle of the field still to be drilled. Drilling operations are now being carried on to the east and southwest, but two dry holes on the west flank will probably slow movement in that direction. The D-2 reef is similar to the comparable formation in the Leduc-Woodbend field, possibly on a more limited scale, and exhibits the early erosive action which splits this type of oil formation into unconnected pools. Because of this, drilling failures in one particular segment of the field do not necessarily discourage further stepouts.

● PRODUCTION DATA: Imperial Oil Company, Limited, discovered the field with Excelsior 1 late in 1949 and the field moved ahead of the other discoveries for that year in terms of monthly production. With five operators in the present field, the development of the productive limits should keep pace with the demand for the oil. No estimate has yet been given for the probable recovery from the area now developed. This is largely due to the fact that any such estimate would be out of date by the time it was published.

The D-2 reef, topped at 3810 in the discovery well, had about 40 feet of productive section. With an initial potential of 1150 barrels daily, the discovery was followed by Rio Bravo Company's (Superior Oil Company affiliate) Excelsior 5-3 to the south and Pacific Petroleum Company's Excelsior 1 a mile east. The first two wells drilled through the D-2 to test for the D-3 zone with no results. The last well topped the D-2 at 3840 and found 60 feet of productive section. Initial potential for this well was 1250 barrels daily and its completion encouraged the rapid development now going on in the field. Daily allowables for the wells are now set at 105 barrels and some of the wells will require artificial lift in the near future. The field follows the general 40-acre spacing pattern, and as there is only one producing section thus far developed, the field presents a uniform pattern of wells and surface equipment. The sweet crude is 35 gravity and the oil is presently moved from the field by trucks. A pipe line is being laid to connect the field to the large line leading from the Redwater field to Edmonton.

The discovery well was drilled on the basis of geophysical data and the field has a record of 28 completions, with six of them being failures.

● DRILLING DATA: Only one rig is now operating in the field, but the comparative inactivity is due largely to the lack of adequate outlets for the oil. The long stepout wells have resulted in dry holes, so activity is presently centered near the producing wells.

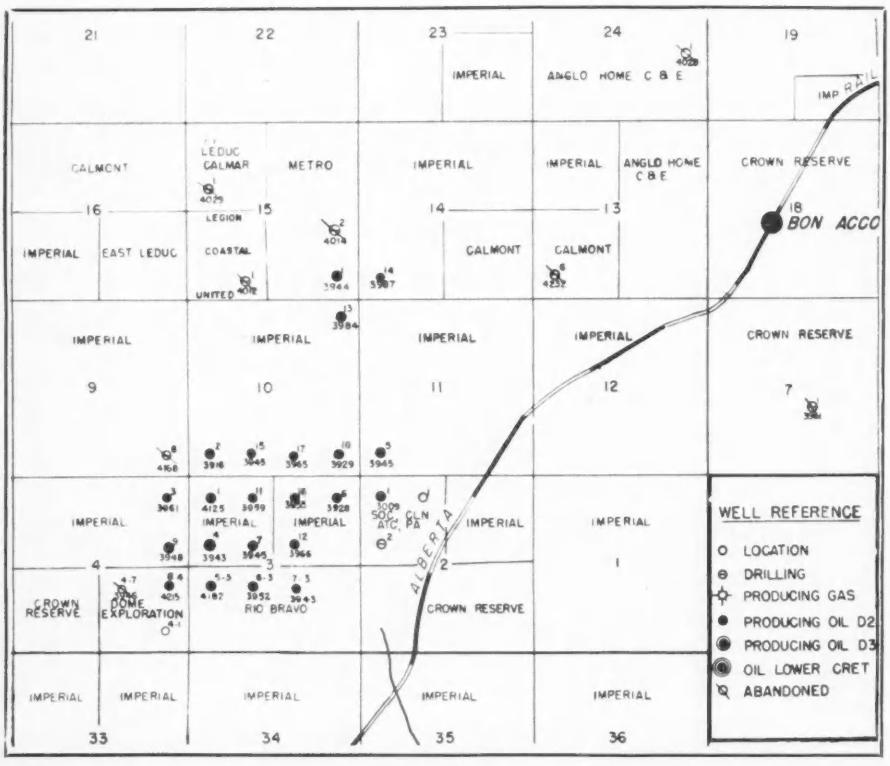
A typical casing program calls for 300 feet of 10¾-inch surface casing cemented to the surface, and seven-inch oil string set on top of the producing zone with 300 sacks of cement. Completions are made through open hole or with a 5½-inch liner set through the pay and perforated. Early wells were not acidized, but more recent wells sometimes are given a wash shot of acid to clean up the well face. About seven 7-inch rock bits are used per well.

Mud programs are seldom required. A gel-type mud is usually used below the surface pipe and lost circulation is seldom a problem. Where it occurs, any bulky material available is used to regain returns.

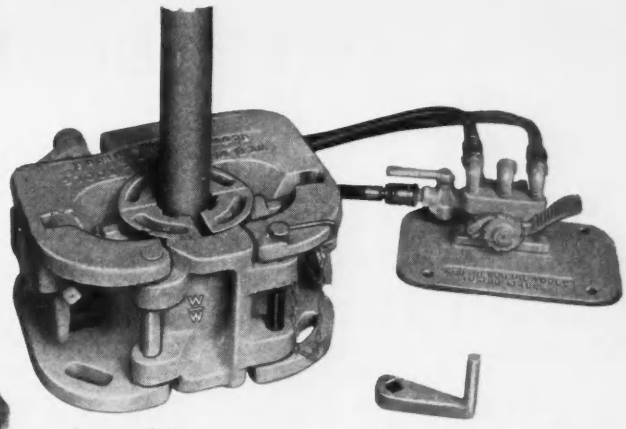
On the portable derricks used in the field, rigup time consumes about one day, with average completion time taking about seven to nine days. Diesel-driven rigs are normally used with 2 medium mud pumps and one shale shaker. Mud pits are excavated and water is obtained from shallow water wells.

Usual drilling rates are $4 to $4.50 per foot; daily rates are from $450 without drill pipe to $550 with drill pipe. Fully equipped well costs about $50,000.

Nearest supply center is Edmonton, 18 miles south. The main road leading to Redwater passes through the field and a portion of it is paved and the remainder gravel. Side roads are mostly dirt and usually difficult to traverse when wet.



we're always uncorking something *new*



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IMPORTANT Canadian FIELDS

STETTLER FIELD

Has Production from Three Zones

PRODUCING from the Lower Cretaceous sand, the D-2 and D-3 limestone reefs, the Stettler field, 90 miles northeast of Calgary, is one of Alberta's more important recent discoveries. Gulf Oil Company found the field in May, 1949, with Ellis 4, which tapped production in the two Devonian reef formations, and the field now contains two Lower Cretaceous, 10 D-2 and 7 D-3 producers. In addition, there are two dual producers in the D-2 and D-3 zones.

It will be noted on the map that the Lower Cretaceous wells are three miles northeast extensions of the main field and the chief play at this time centers on the D-2 and D-3 reefs in the central and south end of the field.

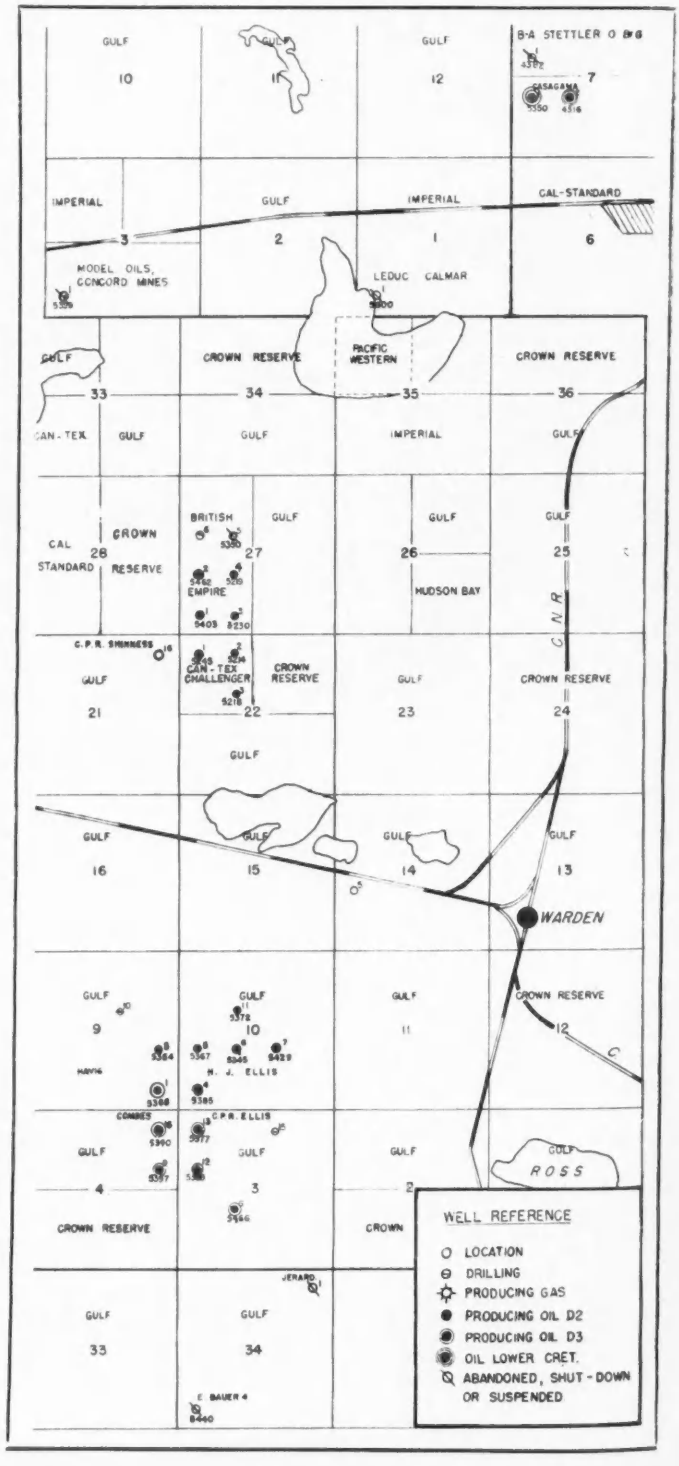
● PRODUCTION DATA: Discovered as a result of detailed geological and geophysical surveying, the Stettler field has thus far developed the D-2 and D-3 reefs as lying in a north-south trend. Gulf's first well, Jerard 1, found the southeast limits of the reefs by drilling into water. Moving updip, Ellis 4 found production of about 1400 barrels daily in the D-2 and 4100 barrels daily in the D-3 zones. Gulf's Bauer 4 later found the two zones unproductive to the south and drilling activities accordingly moved north. The two-mile blank corridor between the present wells has yet to be drilled and will probably add much to the field's potential.

Lower Cretaceous in the area is topped at about 4100 feet and is extremely variable in thickness, depending upon the stratigraphy of the Mississippian below. The D-2 is topped at about 5100 feet and has a variable thickness of about 120 to 230 feet. The D-3 is separated from the D-2 by about 100 feet of shale and is topped at about 5400 feet, having a 50-foot pay thickness. The Viking sand occurs in the field above the Lower Cretaceous sand, but is nonproductive. The D-2 reef wells have a daily allowable of 145 barrels and the D-3 wells, 100 barrels. The field follows the 40-acre spacing pattern and the sweet crude gravity is 28 in the Lower Cretaceous and 31 in the reef pools.

● DRILLING DATA: Three rigs are currently operating in the field and one well being drilled is in the process of testing the D-2 zone. Three new locations have been staked for the rigs to move on when the present tests are completed. Casing programs include about 550 feet of 10¾-inch surface casing cemented to the surface, seven-inch casing set on top of the D-2, or set through D-2 to the top of D-3 where both zones are productive. In the latter case the D-3 is produced through open hole or a perforated liner, later plugged back and the D-2 produced through perforated casing. In the case of dual completions, the casing is packed off so the D-3 produces through tubing and the D-2 through the casing. Frequently, 1000 to 1500 gallons of acid are used to clean up the pay face.

Completion time varies, depending upon the formations found to be productive, but the average runs from 30 to 45 days. Usually, 20 nine-inch bits are used per well. Drill pipe most commonly used is four-inch with five to six 6¼-inch drill collars above the bit. Gel-type mud is normally used for drilling and fibrous material is used where lost circulation occurs in the limestone sections.

Both portable and medium-size derricks do the drilling. Heavy rigs were tried in Canada at the outset of the present oil play but proved to be impractical for the shallow drilling done in most fields. The power rigs use diesel fuel as a rule and each operates two mud pumps and one shale shaker. Footage rates run from $5.50 to $6 per foot and daily rates run from $550 without drill pipe to $650 with drill pipe.



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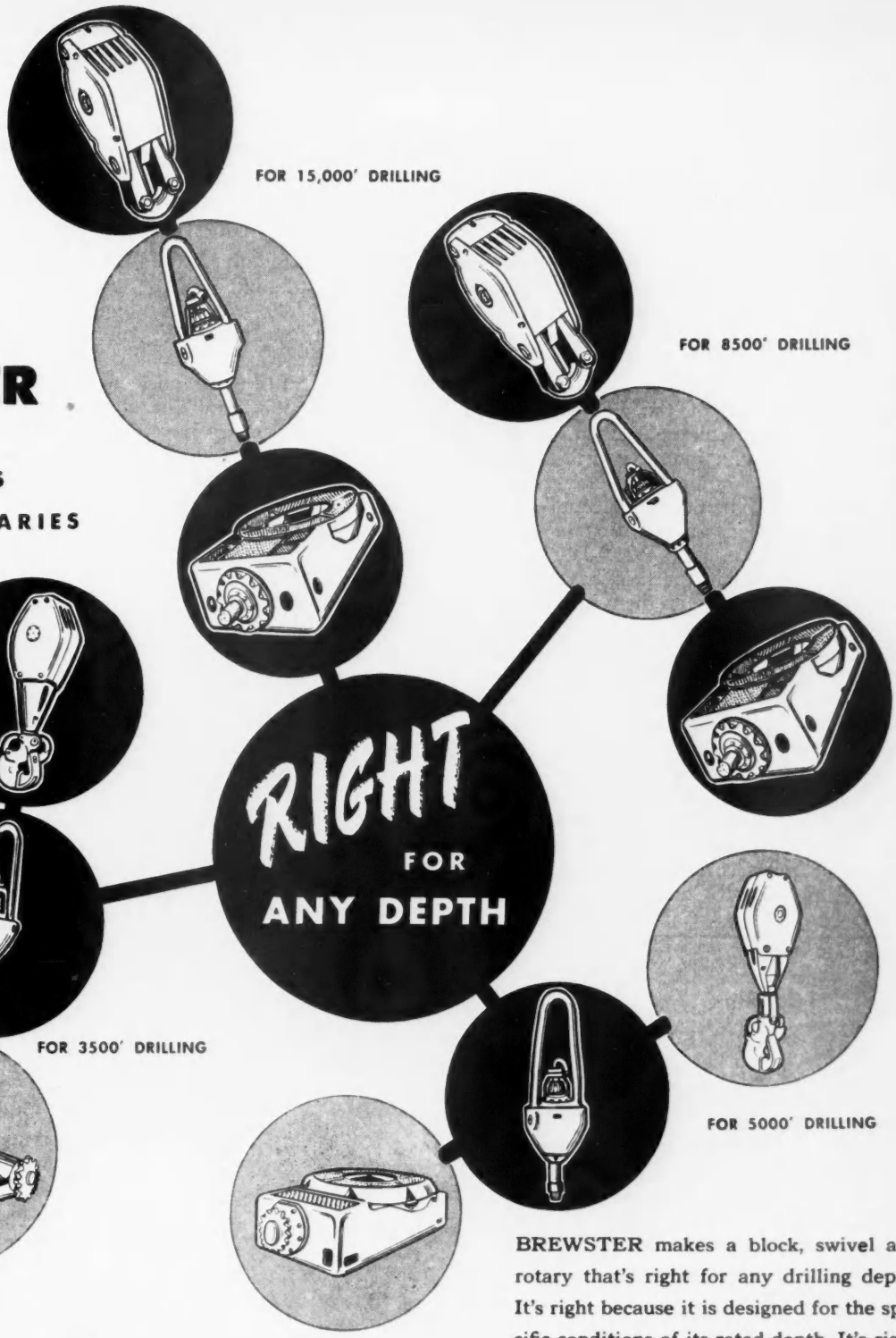

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IMPORTANT Canadian FIELDS

JOSEPH LAKE FIELD

Discovers Viking Production

THE first to find commercial oil production in the Viking sand in Canada, the Joseph Lake field has 21 productive wells since its discovery in March, 1949. Located 18 miles southeast of Edmonton and about 20 miles east of the Leduc-Woodbend field, Joseph Lake is currently undergoing an intensive drilling campaign to complete development of the field. The field had 13 oil wells in September and about a month later had completed 21. The three rigs operating in the field have 16 locations staked to keep them busy for the next two months.

The highly oil productive Viking sand in Joseph Lake occurs in most of the other fields throughout Alberta, but is either nonproductive or contains gas only, as in the Kinsella-Viking field. The Upper Cretaceous Viking sand had oil at about 3250 feet in the discovery well, Joseph Lake 1, which was drilled on the present northwest corner of the field by The Superior Oil Company, Ltd., General Petroleum Company, Ltd., Kroy Oil Company, Ltd., and Jupiter Oil Company, Ltd. The well was drilled to 5215 feet, seeking other production without success. A small section of the D-3 reef showed oil, but not in commercial quantities. The wells drilled after the discovery have not gone beyond the Viking sand and there is an opinion that the field will be re-examined to determine whether or not a D-3 high occurs in the field.

● PRODUCTION DATA: Joseph Lake should prove to be a good oil producer. As mentioned in another section of this issue, the proven recoverable reserves were estimated to be 7.5 million barrels at the time only 11 producing wells had been completed. The productive area was then taken to be 1560 acres, and judging from the location of those first 11 wells, the acreage now has practically doubled. Generally, final recovery will be on the order of 5000 barrels per acre.

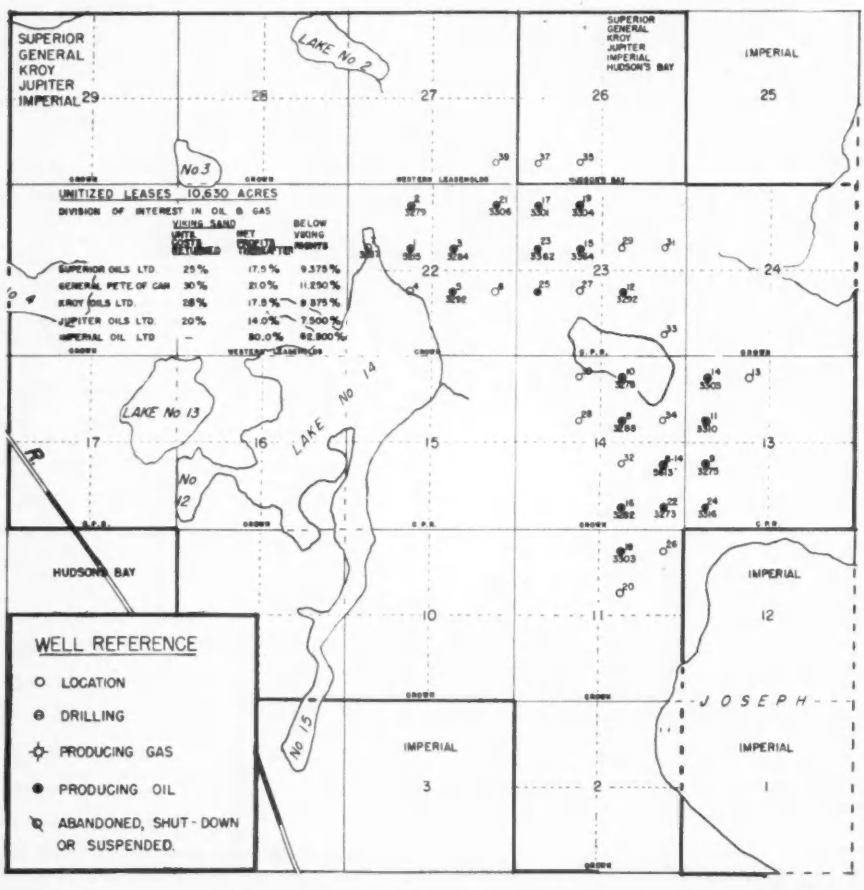
Productive thickness of the Viking sand ranges from 10 to 25 feet, with the upper third usually containing gas. Completions are made by coring through the sand and setting casing a few feet below the sand. Initial potential of the discovery well was about 520 barrels daily from only seven feet of oil section, and some wells in the thicker sand areas have tested 1000 barrels a day. The field is, however, prorated to 50 barrels daily per well. Most of the wells in the field flow at very low gas oil ratios and there is some evidence of a water drive in the northwest. Three wells are presently being pumped and four more are awaiting units. The field is on the 40-acre spacing pattern. The sweet crude has a gravity of 38 and is presently trucked out of the field to Edmonton for the Interprovincial Pipe Line which, incidentally, passes through the field.

● DRILLING DATA: The 16 new locations staked, which will be drilled by the three rigs now in the field, are all direct offsets to producing wells. With the only dry hole in the field located on the northwest tip of present production, there is much room for an active drilling campaign within the unitized lease. No long stepouts have been made as yet.

Typical casing programs call for 300 feet of 10¾-inch surface casing cemented with 150 sacks, and seven-inch oil string set to bottom with 150 sacks of cement. First wells had the casing set through the sand and perforated, but it is common practice now to set through the gas section and drill out below the pipe about five feet into the oil section.

Drilling problems do not exist and light equipment is used throughout, from small 5000-foot rated rigs, portable and conventional derricks, 3½-inch drill pipe, a mud pump and a shale shaker. Drilling time ranges from seven to ten days and about six 9-inch bits are used. There are no mud problems encountered and mud costs are usually negligible, amounting to only the first make-up.

Footage rates run from $4 to $4.50 per foot; daily rates from $450 without drill pipe to $550 with pipe. Fully equipped well costs about $40,000.



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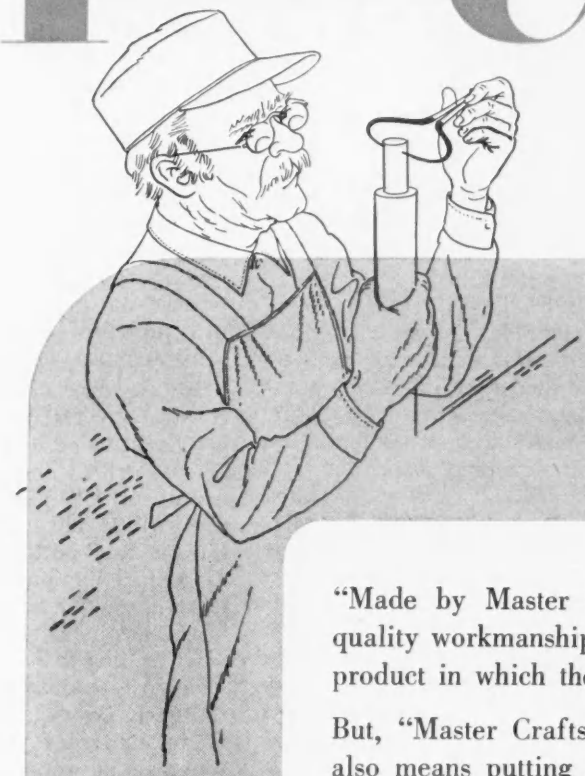

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IMPORTANT Canadian FIELDS

CAMPBELL FIELD

Produces from Lower Cretaceous

EIGHT miles north of Edmonton and to the right of the road now considered part of the Alcan Highway, the Campbell field now has nine producers in the Lower Cretaceous sand. Redwater Leaseholds, Ltd., a Calgary independent group, discovered the field in June, 1949, with Campbell 1, drilled on a seismic anomaly. Imperial Oil Company, Ltd., originally held the lease on the property and had done the geophysical surveying. The two companies shared equally in the Imperial-held leases with Redwater Leaseholds operating the field; later Northern Development Company and Cordasun Petroleum Company, Ltd., joined in to contribute development costs in return for a total of 25 percent net profits. The group presently has seven oil producers on its leases with one failure and one well drilling. Another independent, High Crest Petroleum Company, Ltd., has one oil well in the southwest corner of the field, a short distance from a failure it drilled in November, 1949. Results on this well were not definite at the time of this writing. About one-half mile southeast of this well, Richfield Petroleum Company has completed Campbell 1. A one-half-mile north extension to the field was being drilled by British-American Petroleum Company, Ltd., and a two-mile easterly extension was being attempted by the Phillip Low syndicate. Should the latter two wells find production, the field will undoubtedly see much more activity in the next few months.

Basically, the Lower Cretaceous as it produces in the Campbell field is far from delineated. Structurally, the sand is believed to be a stratigraphic trap-type reservoir the limits of which are not yet determined.

● PRODUCTION DATA: Redwater Leaseholds Campbell 1 topped the Lower Cretaceous sand at 3704 feet and drilled on to 5004 feet seeking Devonian reef production. The D-2 reef was found at 4355 but no production developed, and the D-3 reef also failed. The well was plugged back and the Lower Cretaceous perforated at 3704-20 feet, where the well now produces 40 barrels daily by pump. During the drilling operations the Viking sand showed oil stains at 2960 feet but this zone apparently will not produce in the Campbell field. The effective sand thickness of the Lower Cretaceous throughout the field varies from 15 to 45 feet and some gas is found in most of the wells. Although present in volume, the gas is apparently in a section of noncommunication with the oil zone for there is not an effective gas drive and most of the oil wells have to be pumped.

The Campbell wells have an assigned allowable of 50 barrels a day, and while the initial potentials ranged from 40 to 90 barrels daily, most of the wells stay within the allowable limits with pumping units. The oil is 35-gravity sweet crude with a low percentage of connate water. The oil-water contact appears at about 1568 feet subsea but there is no evidence yet that an effective water drive will develop. Oil production is currently trucked out of the field, but the field will probably be connected to the Redwater pipe line to Edmonton.

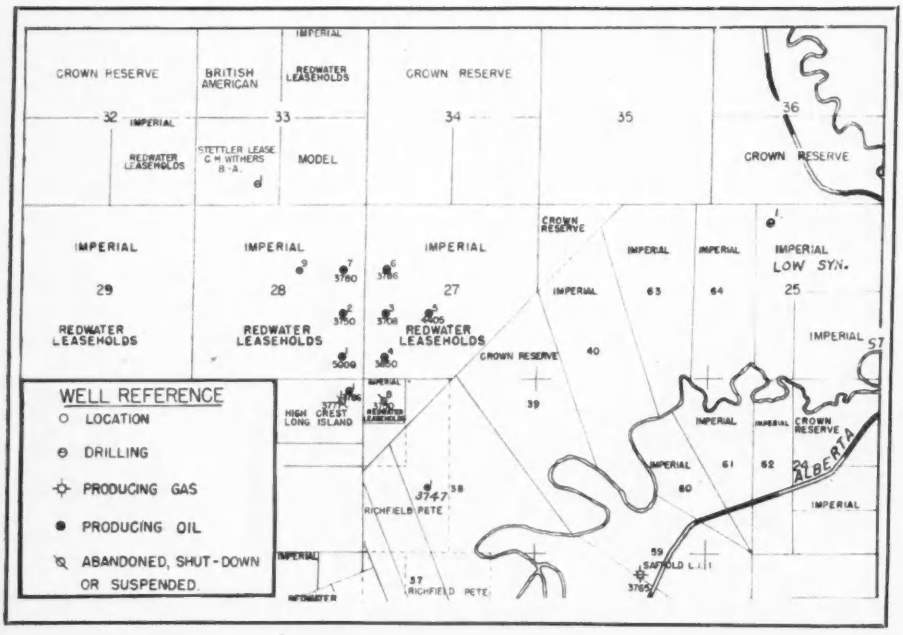
An example of the erratic results obtained by drilling in the Campbell field is provided by High Crest-Campbell 1, drilled to 3777 feet without results in 1949. The company's second well drilled 320 feet northeast of the failure, and bottomed at 3786 feet, found production. Redwater Leaseholds-Campbell 8 failed 1320 feet east of the second High Crest-Campbell 1 after drilling to 3750 feet. This would seem to discourage development in a southerly direction, but Richfield-Campbell 1 was successful three-fourths mile southeast of Campbell 8, after drilling to 3747 feet. On the basis of these developments, most of the area around the present field is still wide open.

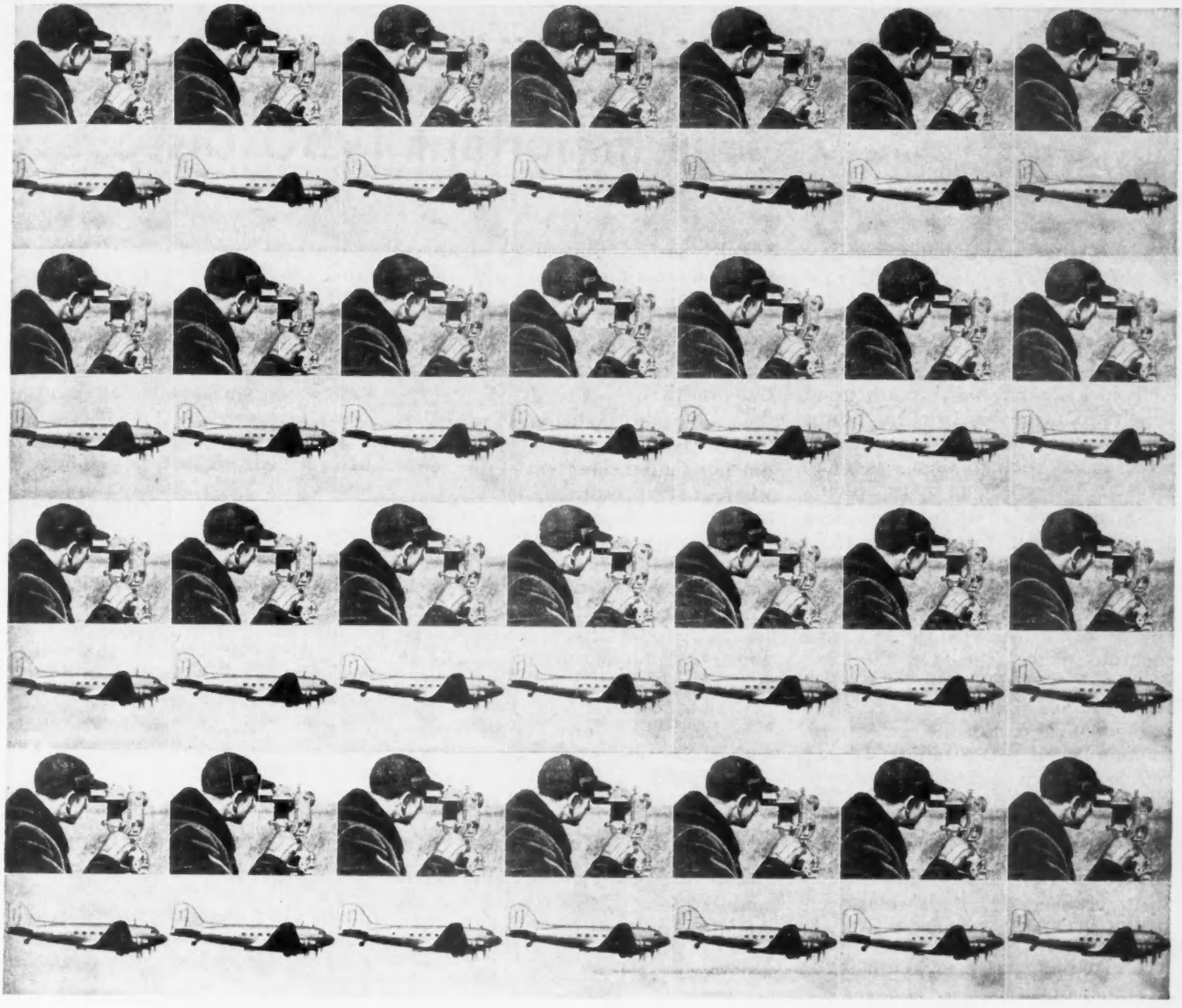
● DRILLING DATA: Three rigs are now operating in and around the Campbell field. If the British-American northwest stepout and the Low Syndicate's east stepout prove productive, drilling activities will be accelerated markedly.

Typical casing programs include 300 feet of 10¾-inch surface casing set with 150 sacks of cement and seven-inch casing set through the oil sand with 150 sacks of cement and the oil section gun perforated.

Medium-size and portable rigs are used in the field, with one mud pump and one shale shaker. About 15 days are required to drill each well and about 10 nine-inch rock bits are used. Mud problems are negligible, with gel-type mud being used as a rule below the surface pipe. A fully equipped well costs about $50,000.

About five miles northwest of the Campbell field, the 1948 Volmer discovery failed to develop into a field after two dry holes were completed, and the only producing well there was abandoned late this year.





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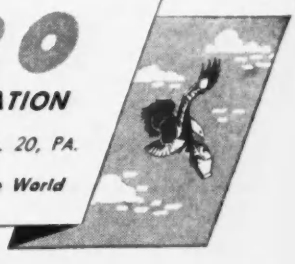

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IMPORTANT *Canadian* FIELDS

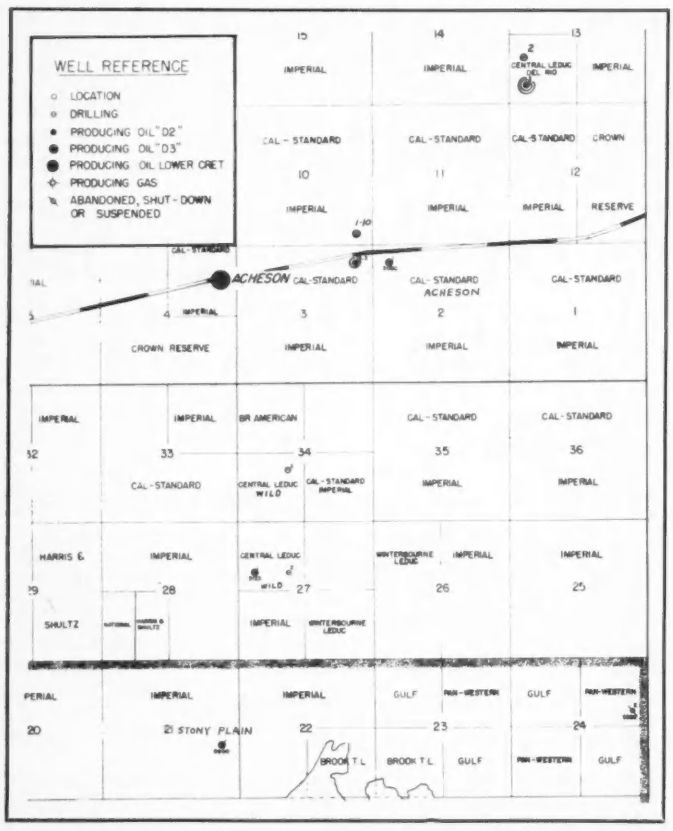
ACHESON-STONY PLAINS FIELD

Is Important 1950 Discovery

PROBABLY one om the most important 1950 oil discoveries in Canada is the Acheson-Stony Plain field, about eight miles west of Edmonton. With the discovery of two wells in September, there are now five wells in a six-mile north-south trend which produce either from the Lower Cretaceous sand, the D-2 or the D-3 reefs. In addition to these, six more wells are either rigging up or drilling.

The discovery of the field is credited to Standard Oil Company of California, Ltd., and Imperial Oil Company, Ltd., who were carrying on seismic and structural exploration in the area on their jointly held and separate reservations. On the basis of the seismic data obtained, California-Standard drilled a deep wildcat four miles east of the present production but it was a failure. It then moved over to Acheson-Province 1, shown in Sect. 2 of the field map, and commenced drilling in July of this year. At the same time Imperial started Stony Plain 1, 3½ miles southwest, in Sect. 21. Both wells were completed in September, with the Stony Plain 1 finding about 100 barrels a day in a thin section of the D-3 limestone reef and the Acheson-Province 1 finding about 1600 barrels a day in 120 feet of the D-3 reef. The results in the latter well moved activity north.

Structurally, Acheson-Province 1 topped the D-3 reef at 4969 feet and did not find the bottom of the zone where it stopped drilling at 5090 feet. Stony Plain 1 had found only six feet of oil section before entering water. Central Leduc Oil Company, Ltd., a Calgary independent, drilled Wild 1, 1½ miles north of Stony Plain 1 and two miles southwest of Acheson-Province 1, finding top of the D-3 at 5117 feet and getting only nine feet of pay section. On drill-stem test in the D-3, Wild 1 flowed oil to the surface in 11 minutes and the well was completed in that zone as a pumper September 19. Wild 1 had earlier found substantial gas production in the Viking sand and commercial oil production in the Lower Cretaceous and D-2 zones. Where production is found in more than one section, the wells are produced from the bottom sections first. The completion of Wild 1 raised the question as to whether it and Imperial's Stony Plain 1 were on the east or the west flank of the D-3 reef. There have been no distant stepouts in either direction as yet to answer the question.



Central Leduc then teamed up with Del Rio Oil Producers, Ltd., and others to drill Central-Del Rio-Acheson 1 about 1¼ miles northeast of the Acheson-Province 1 discovery. This well was completed in the Lower Cretaceous sand, topped at 3960 feet, for about 2000 barrels a day. Of significance was that the D-3 reef in the well produced water only, but the well opened up new prospects for the Lower Cretaceous sand in the budding Acheson-Stony Plain field.

Meantime, California-Standard had drilled Wellbourne 16-3 as a west offset to the Acheson discovery. Completion was in the D-3 reef, topped at 4960 feet, for a potential of 1450 barrels a day. This well had found substantial production in the D-2 reef, at 4641 feet, and it was originally planned to complete the well there. Wellbourne 16-3 drilled over 120 feet of oil section in the D-3 without encountering water.

Central Leduc was following up Wild 1 with a direct east offset and a mile northeast extension. Both wells were nearing total depth at the time of writing. Central Leduc-Del Rio et al. were drilling a north offset to their Acheson 1 Lower Cretaceous success. A 3½-mile stepout south of Imperial's Stony Plain was being drilled by Redwater Petroleum Company and Piccadilly Petroleum Company, and at last report the well was below the average D-3 zone depth and was preparing to run electric log.

As the Acheson-Stony Plain field now stands the thickest section of D-3 production occurs at the north end of the lane of wells drilled. Two wells have found a flank of the D-3 reef to the south, but it has not yet been determined which side of the reef they represent. Lower Cretaceous sand production has been established some distance north of the reef pay in the Central Leduc-Del Rio well, a condition quite similar to the Leduc-Woodbend field.

Medium-size rigs are being used to drill in the area. Casing programs in the first wells included 600 feet of 10¾-inch surface casing set with 300 sacks of cement and seven-inch oil string set through the gas section in the D-3 with five to ten feet drilled out below the casing. The seven-inch is cemented with about 225 sacks of cement. If completion is to be made in the D-2 or Lower Cretaceous zones later the casing will be plugged back and perforated. The gravity of the D-3 oil is 36.5.

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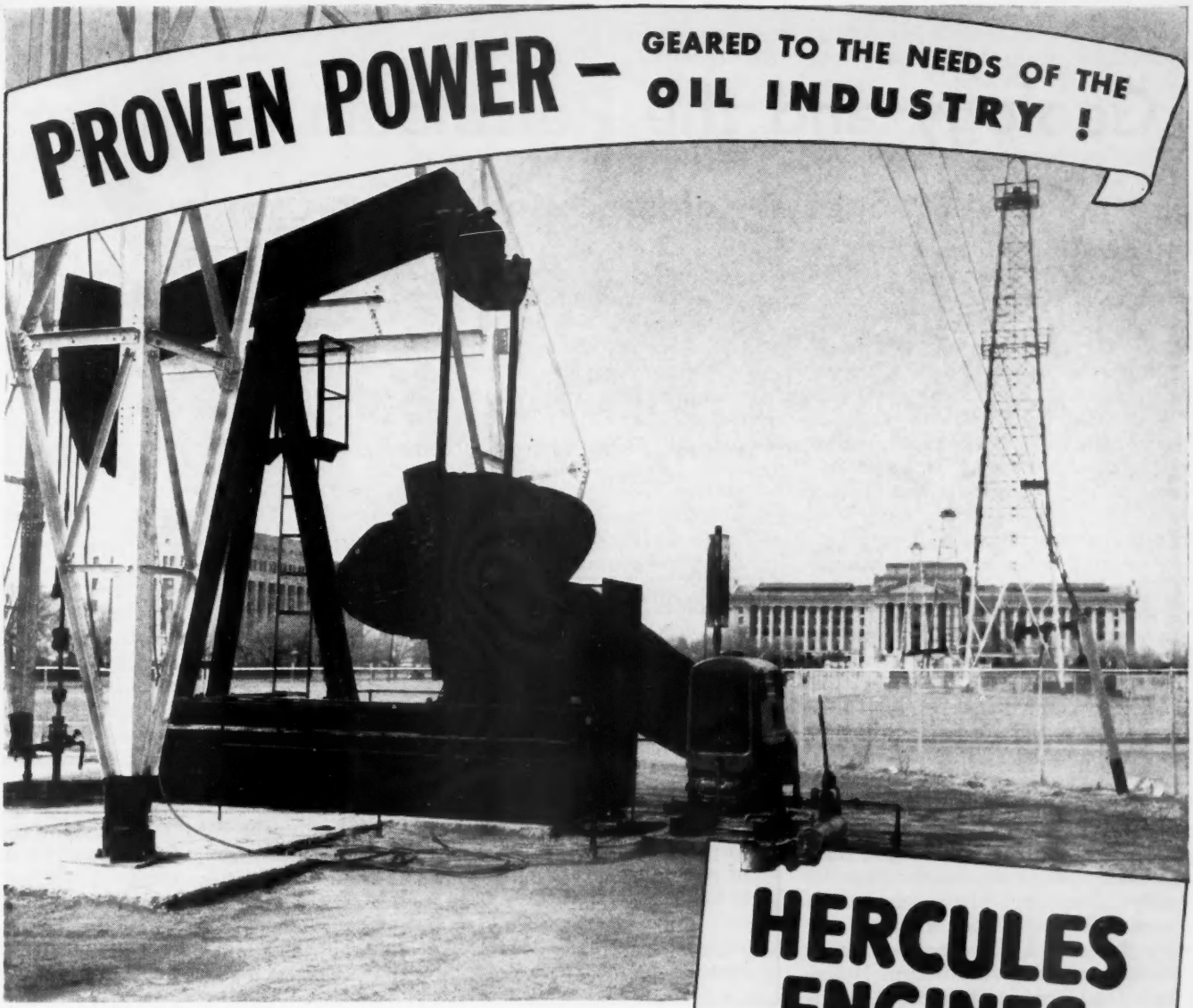

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NXA	3" x 4"	56.5
NXB	3¼" x 4"	66.3
Four Cylinder		
ZXA	2½" x 3"	59
ZXB	2⅞" x 3"	65
IXA	3" x 4"	113
IXB	3¼" x 4"	133
JX4E	3½" x 4¼"	164
JX4C	3¾" x 4¼"	188
JX4D	4" x 4¼"	214
Six Cylinder		
QXA	3⅛" x 4⅛"	190
QXB	3¼" x 4⅛"	205
QXC	3⅜" x 4⅛"	221
QXLD	3 7/16" x 4¼"	236.7
JXE	3½" x 4¼"	245
JXB	3⅝" x 4¼"	263
JXC	3¾" x 4¼"	282
JXD	4" x 4¼"	320
JXLD	4" x 4½"	339
WXC-3	4¼" x 4½"	383
WXLC	4" x 4¾"	358
WXLC-3	4¼" x 4¾"	404
TDXB	4⅛" x 5¼"	474
RXB	4½" x 5¼"	501
RXC	4⅝" x 5¼"	529
RXLC	4⅝" x 5¼"	529
RXLD	4¾" x 5¼"	558
RXLDH	4¾" x 5¼"	558
HXB	5" x 6"	707
HXC	5¼" x 6"	779
HXD	5½" x 6"	855
HXE	5¾" x 6"	935

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DIXD	4¼" x 4½"	127.5
Four Cylinder		
DIX4B	3¼" x 4"	133
DIX4D	3⅜" x 4"	166
DOOB	3¾" x 4½"	198.8
DOOC	4" x 4½"	226.2
DOOD	4¼" x 4½"	255
Six Cylinder		
DIX6D	3⅝" x 4"	249
DJXB	3½" x 4½"	260
DJXC	3¾" x 4½"	298
DJXH	3¾" x 4½"	298
DJXHF	3¾" x 4½"	298
DWXC	4" x 4¼"	358
DWXD	4¼" x 4¼"	404
DWXLD	4¼" x 5"	426
DWXLDF	4¼" x 5"	426
DRXB	4⅛" x 5¼"	474
DRXC	4⅝" x 5¼"	529
DFXB	5" x 6"	707
DFXC	5¼" x 6"	779
DFXD	5½" x 6"	855
DFXE	5⅝" x 6"	895
DFXH	5¾" x 6"	935
DFXHF	5¾" x 6"	935
Eight Cylinder		
DNX V-8B	5¾" x 6"	1247
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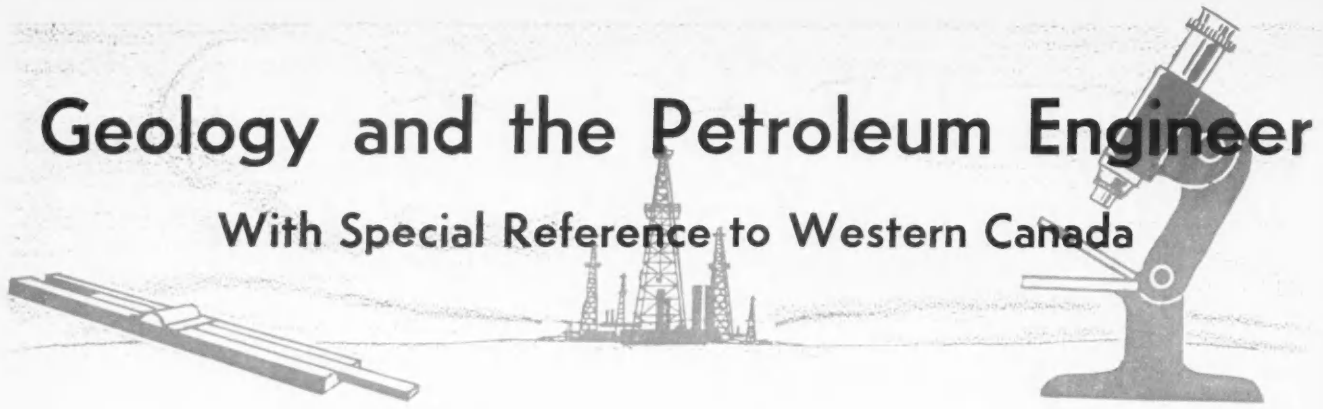


Geology and the Petroleum Engineer

With Special Reference to Western Canada

By H. H. BEACH

Chief Geologist, Texaco Exploration Company
Calgary, Alberta

IN THE DEVELOPMENT of new petroleum sources the engineer and geologist have many methods of approach and procedure which could well be interchanged to their mutual benefit. In comparing the work of the petroleum engineer and geologist, the author discusses the development of reef reservoirs in general and the exploitation of these prolific sources of oil in Canada. This paper is from a talk presented before the AAPG regional meeting at Banff, Alberta, September 5-8.

IT IS widely recognized that geologists and engineers generally approach problems of mutual interest and concern from quite different points of view. Reasons for this divergence stem not only from quite fundamental differences in technical training and experience but commonly from a differing basic philosophy regarding the nature of the conclusions and the extent of generalizations each is prepared to make from the same factual information. Rarely, indeed, do geologists have before them more than a small percentage of the desirable data in drawing conclusions concerning geological problems. Nevertheless, a liberal application of imagination in dealing with the facts at hand has, at times, led to oil discoveries of great commercial importance. The train of reasoning involved may be such as to put to shame the intuitive efforts of the most successful detectives of fiction.

Engineers are inclined to look askance at conclusions not supported overwhelmingly by the facts. Both points of view have their place in oil finding and development. This paper hopes to shed a little light on how the application of one approach may be beneficial in the other.

Before embarking upon the theme concerning the aid that a knowledge of geology can be to the practicing petroleum engineer, it seems desirable to distinguish between the respective roles of the petroleum geologist and the petroleum engineer in the common objective of finding and developing profitable sources of oil and natural gas.

The petroleum geologist's task is concerned primarily with the finding of prospects of sufficient merit to justify drilling. As such, he is associated largely with exploration. Once a strike is made, the petroleum engineer takes over to conduct the orderly exploitation of the field discovery and the appraisal of its reserves. On the surface, the tasks would seem quite distinct. In practice, however, the two merge over a broad zone. Every time an engineer, through careful appraisal of electric logs and well performance data, finds new productive sands or field extensions in known horizons, he is performing the role of the geologist. Similarly, geologists are becoming increasingly aware that logical appraisal of fluid characteristics in wildcat and development wells can provide important leads to new traps, particularly of the stratigraphic and updip pinchout types.

A highly fanciful story will serve to bring out a fundamental difference between the geological and engineering approaches to a problem.

Assume that a corporation has under consideration the building of a bridge from an island across to the mainland, and knowledge of the length of the proposed bridge is urgently required for budget purposes. An engineer and a geologist were dispatched to get the desired information. Let it be assumed that they arrived at the site on a bright, sunny day, the engineer quickly determined the distance from the mainland to the island by the application of well known triangulation methods. Now suppose that upon arrival at the location of the mainland pier, it was found that a dense fog had settled and the island was obscured from view. Use of standard engineering methods was not possible. The geologist then commenced an accumulation of intangible evidence (Figure 1). He mapped carefully the variations in the lithology and the size sorting of sands and gravels along the mainland beach, the direction and force of currents approaching the shore, and the position of near-shore bars. This he combined with knowledge of the structure and stratigraphy of the mainland area and deduced an approximate position where the competent, resistant beds that could reasonably be expected to form the island might lie. A rough estimate of the length of the proposed bridge satisfactory for preliminary budget purposes was thus deduced. It might well be argued that only under the ideal conditions presented could a satisfactory solution to the problem be expected. It should be kept in mind, however, that if the island exists at all, there is a good geological reason for its presence. When that reason is determined, the problem is greatly simplified. This story serves to illustrate the application of imaginative thinking to engineering problems.

The illustrations to follow are likewise chosen to show that imaginative thinking, which is the essence of successful geological work, can be of

the greatest aid to the petroleum engineer in the more realistic solution of many problems.

In the history of an oil discovery, the petroleum engineer is concerned first with the successful drilling and testing of the wildcat that leads to the discovery, then the development of the field and the investigation of the reservoir and estimation of the reserves contained therein. The last subject will be considered first inasmuch as the estimation of reserves the efforts of the engineer and geologist can be combined particularly well to produce results of great economic significance.

Folded Structures

Assume that three wells have been drilled in an area in the Alberta Foothills. Each has struck oil in the Mississippian Rundle limestone. The elevation of the top of the producing horizon and the thickness of pay are as shown on Figure 2. Superimposed upon these basic data is a reasonable contour picture on the top of the pay constructed solely with the data at hand and without recourse to the geological history of the area. Reserves could be calculated with seemingly reasonable certainty within the triangle formed by the wells and the estimates augmented by extending the apparently proven area beyond the triangle by amounts left to the discretion of the individual, in keeping with "good engineering practice." On this picture, it would seem justifiable to drill an additional stepout well at point A to extend farther the width of the productive zone. Now apply information provided by geological study of the area either through surface mapping or seismic investigations, or a combination of the two. Surface mapping has indicated that the exposed rocks have been folded with the regional strike in a northwest-southeast direction. An anticlinal axis can be delineated on the surface and also the magnitude of the north and south plunge of the structure along the axis can be determined. The fold is found to be asymmetrical with the east flank at dips exceeding 45 degrees. By the careful application of geometrical principles (1) it is possible to project the fold downward in cross-section and to determine with a high degree of accuracy where the fold axis will intersect the pay zone. The reconstructed cross-section and contouring on the top of the pay zone shown in Figure 3. Then introduce one further observation. A crushed zone, where circulation was lost, was found in No. 2 well above the pay zone and a thrust fault was mapped on the surface at the point midway between Wells 2 and 3. Knowledge of fault characteristics of the region permits joining these two points of fault observance in cross-section, and its projection to the north and south on surface. The final reconstructed vertical section and the final contouring on the top of the pay is as shown on Figure 4.

It is not suggested that a conscientious petroleum engineer would have been satisfied with the first structural interpretation in the face of the geological data available. It is important to emphasize, however, that had any piece of geological evidence, be it direction of strike, position and form of the fold, nature of plunge or evidence of faulting, been neglected in the final contouring, an erroneous picture of the reservoir would have resulted. It is evident from the diagrams that drilling of a stepout well at A would be a fruitless venture. The imaginative engineer will commence to speculate on the possibilities of a gas cap on the structure and take this into consideration in computing reserves within the bounds of the established waterline.

Reefs and Reef Reservoirs

The waking hours of the greater number of geologists in Alberta are devoted to the study of the nature and distribution of reefs. There is some tendency among major operators to assign the greater part of the development of reef and other fields to the petroleum engineers while geologists are encouraged to concentrate upon exploratory problems, trying to find new plays worthy of drilling. Thus, engineers operate in areas wherein lies the greatest concentration of invaluable geological data. The imaginative engineer is in a position to contribute markedly to our knowledge of reefs and do geological work of a very high calibre. The austerely practical may regard a reef only as an irregular blob of limestone or dolomite, riddled with porosity and saturated with oil above an established waterline. True, such an attitude, coupled with the application of tried and proven engineering principles, will ensure the adequate development of a uniform field. Unfortunately, reefs are far from uniform. An intelligent appreciation of their nature and geological history will create an awareness that will permit the handling of deviations from the normal when they are encountered.

Let us attempt to reconstruct the major phases in the development of a reef to see what help such knowledge

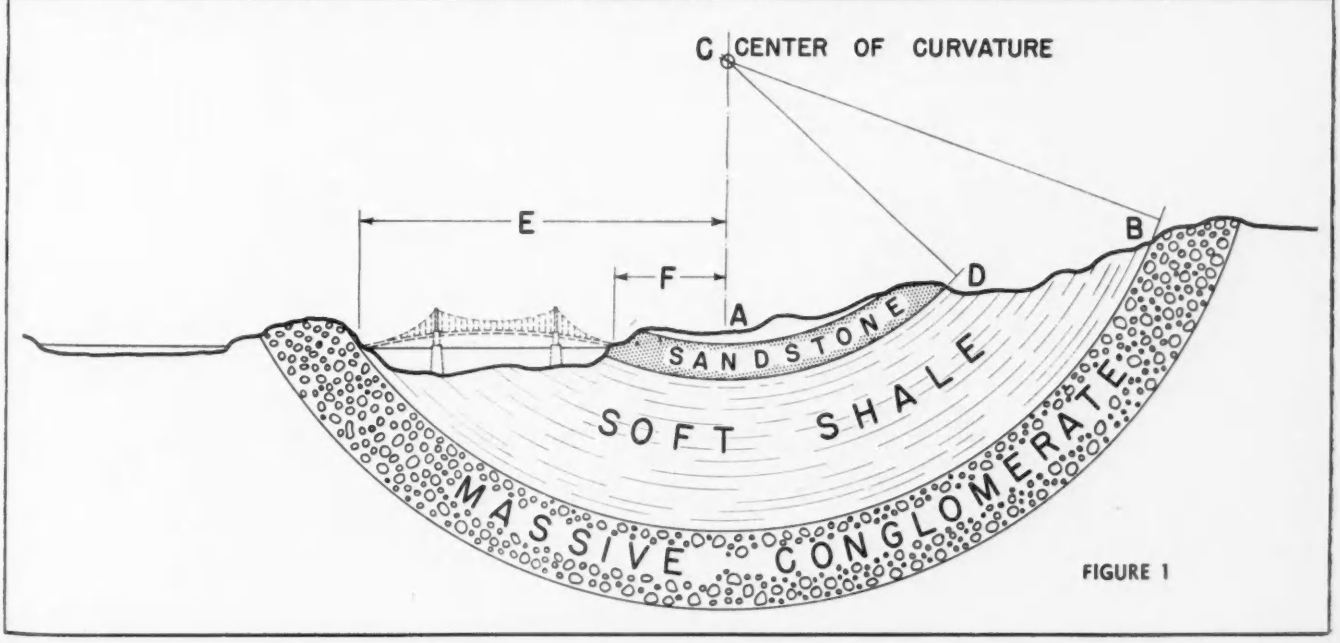


FIGURE 1

can be to the engineer primarily concerned with the form of the reservoir and the nature and distribution of its porosity and permeability. We cannot know exactly the conditions that favored reef growth in past geological periods, such as Devonian time. In keeping with one of the great principles of geology, it must be assumed that general climatic conditions and rates of sedimentation, erosion, and biological development over the earth have remained remarkably uniform over hundreds of millions of years. Thus, reasoning from our knowledge of conditions necessary for reef development today, it may be assumed that satisfaction of at least the following is essential to the founding and building of a reef:

- Warm, clear, sea water, rich in micro-organisms and with a salinity not greatly exceeding 40 parts per million.
- The presence of some form of rock platform over which the water is not more than 20 to 25 fathoms deep, thus permitting the penetration of light necessary for photogenetic processes regarded as essential to coral and algal development.
- Existence of gentle currents necessary to bring food to the sessile forms, but protection from the stronger wave action that could do serious damage to the newly started coral polyps and algal buds.

Growing Reef

Once these conditions are satisfied, a great host of forms accumulate to erect a mound expanding upward to the light. The term "mound" fails utterly to express the riot of color and the activity that surrounds the growing reef. It is not difficult to picture the activity that must have prevailed in the Devonian seas of Central Alberta—yawning clam-like forms, the waving arms of brilliantly colored primitive sea lilies and the flashing shadows of myriads of sharks darting along the reef face. If conditions remained unchanged, the mound would continue to grow until it reached the water surface, giving the general pinnacle form of Figure 5 (A). Many such reefs are today prolific oil fields.

Examine briefly some factors that can cause changes in the reef form and thus in the shape of the ultimate reservoir. Strong currents set up by prevailing winds can favor more rapid growth on the protected side and lead to forms of eccentric outline. A potent factor in this respect is gradual rising or lowering of the sea floor with attendant change in depth of water over the reef. If rate of reef growth equals the rate of submergence, then uniform pinnacle reefs of great height up to 1000 feet or more can result. If the balance is disturbed, however, growth will progress into the areas of shallower water with the attendant production of more bizarre but not uncommon outlines such as are suggested in Figure 5 (B). All reefs present continuous targets for the destructive forces of waves and currents. Fragments of dead organisms are being continuously torn off to fall at the base of the reefs or to accumulate in outwash aprons farther removed. Such detritus accumulates and may create beds with sufficient extent and porosity to form secondary reservoirs.

Reef form can also be modified by channeling through surf and current action leaving areas of "want" through what was once continuous reef. It is readily apparent that prediction of even the form of the reservoir is hazardous. Constant study of past drilling and the maintenance of up-to-date maps combining geological, seismic and well performance data are

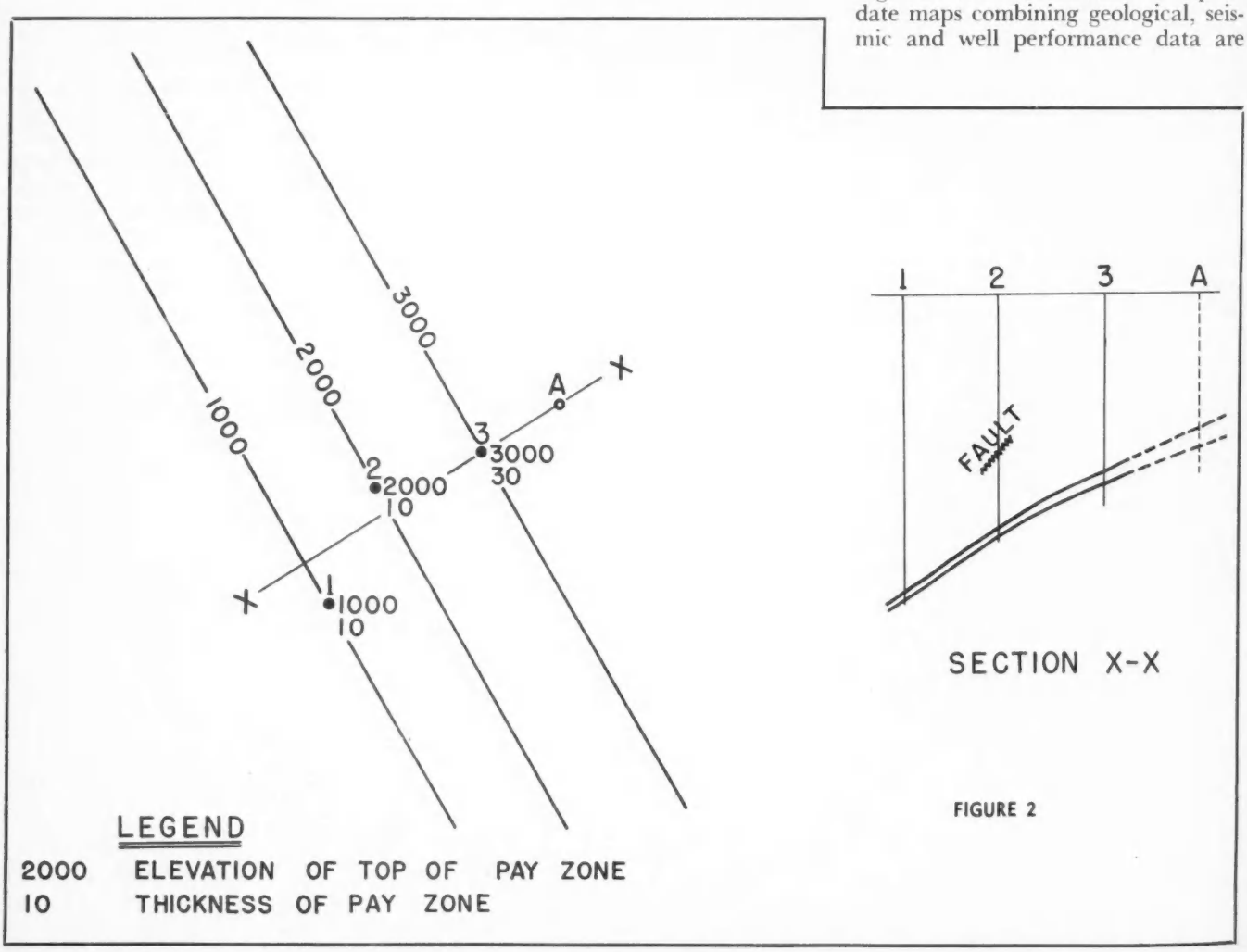


FIGURE 2

essential if the drilling of non-productive wells is to be avoided.

Factors Affecting Porosity and Permeability Within Reefs

A. *Variations in Biological Assemblage*

Reefs are commonly regarded as being composed largely of corals. Actually, corals may form only an insignificant fraction of the total volume. Algal forms generally predominate. Our Devonian reefs show a marked concentration of now extinct bulbous forms called stromatoporoids. Such forms can have a very high degree of inherent porosity due to their structural framework. In growth, stromatoporoids seem to have developed through the addition of concentric layers each of a highly porous nature. In form and structure they are not unlike heads of cabbage. Not only the pore spaces but also the spaces between layers are interconnected to assure excellent overall porosity. Devonian corals, on the other hand are generally much less porous. It would take very careful study to zone a reef on a basis of the distribution of different biologic forms with differing porosity and permeability characteristics in their fossil remains. Nevertheless, a clearer appreciation of this variant may lead to explanations of the distribution of some of the tight zones within reefs.

It is not uncommon to find excellent vug porosity development at the margins of reefs. It is suspected too that parasitic organisms act upon dead and living reef forms changing delicate structures into unrecognizable blobs of structureless limestone. This action apparently is permitted to go on in the sheltered interior of reefs to a greater degree than at the margins.

B. *Subaerial Erosion of Reef Tops*

If at any time during the development history of a reef, the top is bared to the air, circulating ground waters can create excellent porosity and vertical permeability to considerable depths both in the core and along the margins of reefs, even to the point of creating a karst topography replete with caves and sink holes. Selective dolomitization of the limestone, with attendant increase in pore space, may occur through the downward percolation of magnesium-laden waters. It is suspected, however, that most reefs that are dolomite today were converted from limestone either contemporaneous with or shortly after their development. Not uncommonly, large blocks of reef material slough off or move differentially to create fracture patterns that upon enlargement, through solution, augment the voids and add greatly to the over-all porosity. It sometimes happens that a reef may form the favorable locale or base for the development of a subsequent reef at a later time. Indeed, several seemingly unconnected reefs may develop one over the other within a limited area. If each should have its own oil-water interface, the possibilities of multiple pay production are enticing. On the other hand, the intervening strata may account for some of the tight zones commonly encountered.

These few examples fall far short of being an exhaustive and systematic analysis of the relationship of porosity and permeability to reef forms. They will, however, serve to emphasize the close relationship of reservoir characteristics to the geological history of a reef.

Necessity of Detailed Study

Because of the heterogeneous nature of reefs, it is reasonable to expect marked variations in porosity within limited areas from vugs larger than a man's head to microscopic intergranular porosity. Many phenomena may have caused these pore spaces—dolomitization of limestone, fracturing,

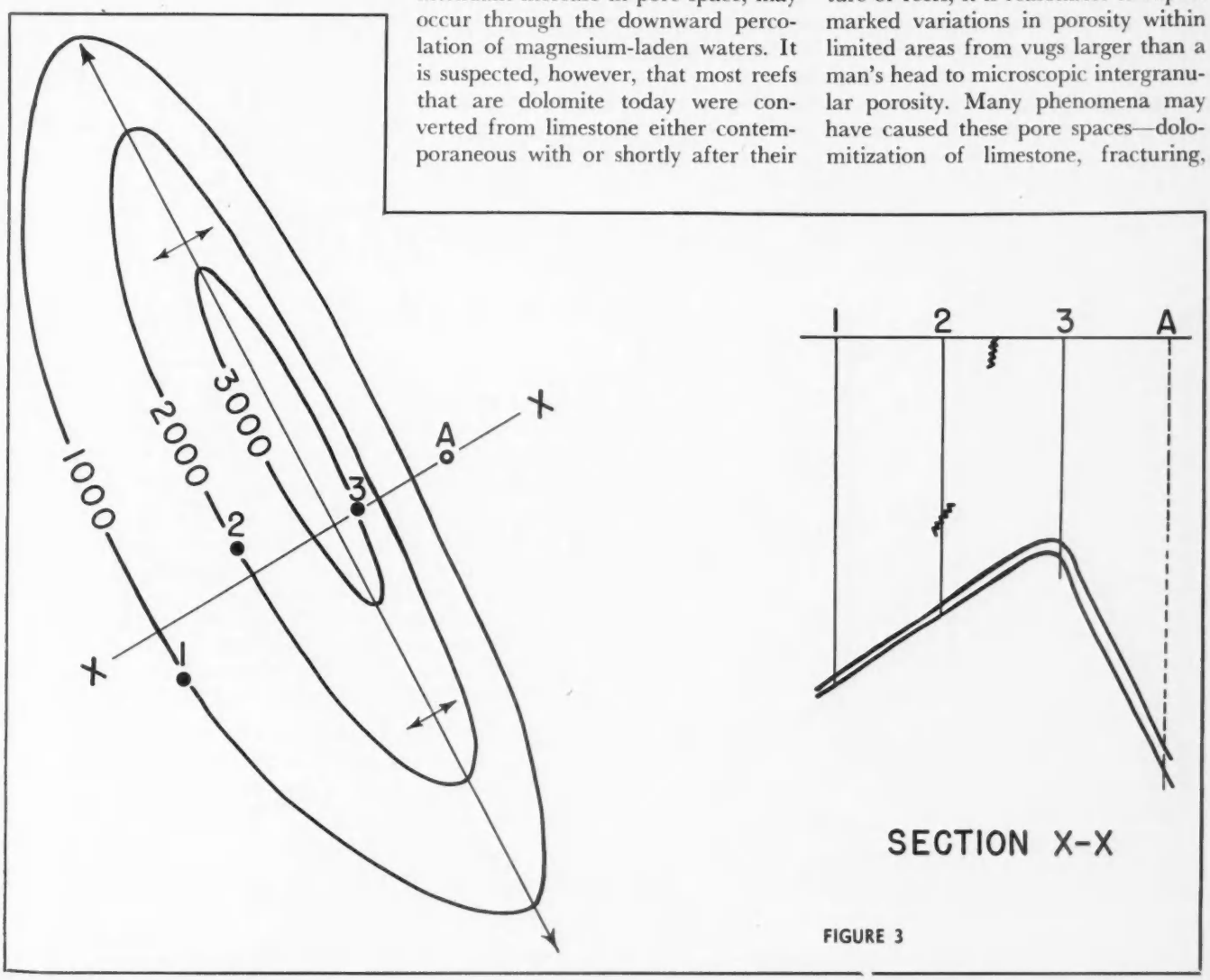


FIGURE 3

differential solution and natural porosity of the fossil forms. It is essential that as much as possible be learned about the types and distribution of porosity within the reservoir through visual study of cores and analyses in order that the most efficient completion practices, rates of withdrawal and gas-oil ratio factors be established. This can be accomplished only by intense co-operative effort by both engineers and geologists. The point that is to be stressed particularly is that these studies should be made early in the life of the field. The programs for recovery once instituted are commonly followed for many years even until the field is pronounced exhausted. Faulty judgment in these matters in the early stages of development can do irreparable harm and may result in the bypassing of a large percentage of otherwise recoverable oil.

Coordination in Wildcat Drilling

Great strides have been made in the application of geological and engineering thinking in the study of reservoirs along the lines discussed above. In the field of wildcat drilling and regional studies where the problems are less clear cut, the coordination of effort has been much slower. It has long been the practice for geologists to draw up a prognosis indicating the depths at which important market horizons are to be expected in drilling and where coring should be done. Such prognoses are prepared primarily for the guidance of the geologist on the wildcat well. Too seldom are prognoses expanded to include information that could be used by the petroleum engineer and drilling superintendent entrusted with the drilling and testing program. From past experience in a region, it should be possible for the geologist to anticipate zones of caving and heaving shales, near surface gas zones presenting blowout hazards and porous beds where loss of circulation could reasonably be anticipated. Two illustrations will suffice to show that substantial savings in drilling costs would be effected by closer geological-engineering liaison.

It is well known that the over-all thickness of the sedimentary rocks overlying the basement increases greatly westward across the Alberta Plains to the foothills. Many thick series of strata unknown beneath the plains appear in the foothills area. Some of these beds contain massive sections of cherts and quartzitic sandstones such as are present in the Rocky Mountain formation of Pennsylvanian and Permian age. The general aerial distribution of this formation is tolerably well known. It would be helpful indeed to those entrusted with the drilling to be able to anticipate the drilling conditions associated with such dense, hard beds and have on the lease bits and other equipment adequate for their rapid penetration.

Anhydrite in the section has always presented problems in drilling through its tendency to flocculate drilling mud. Sufficient information is available whereby the areal distribution of the various anhydrite zones within the Devonian of Central Alberta is quite accurately known. Forewarned, the engineer can arm accordingly.

Correlation of Strata

One of the major problems that confronts the geologist making regional studies is the proper correlation of strata in areas where wildcats are widely spaced. Formations do not maintain a uniform lithology over wide areas, but rather undergo profound changes in lithology, thickness and even in position in the section relative to other recognizable markers.

Correlation of strata is generally made on the basis of any or all of the following:

- Similarity of lithology as revealed by sample and core study.
- Similarity in sequence of the different members in the succession.
- Similarity of fossils contained in the correlative strata.
- Similarity of characteristics as revealed by the various types of electric logs.

Correlation employing all factors enumerated is not always possible, and

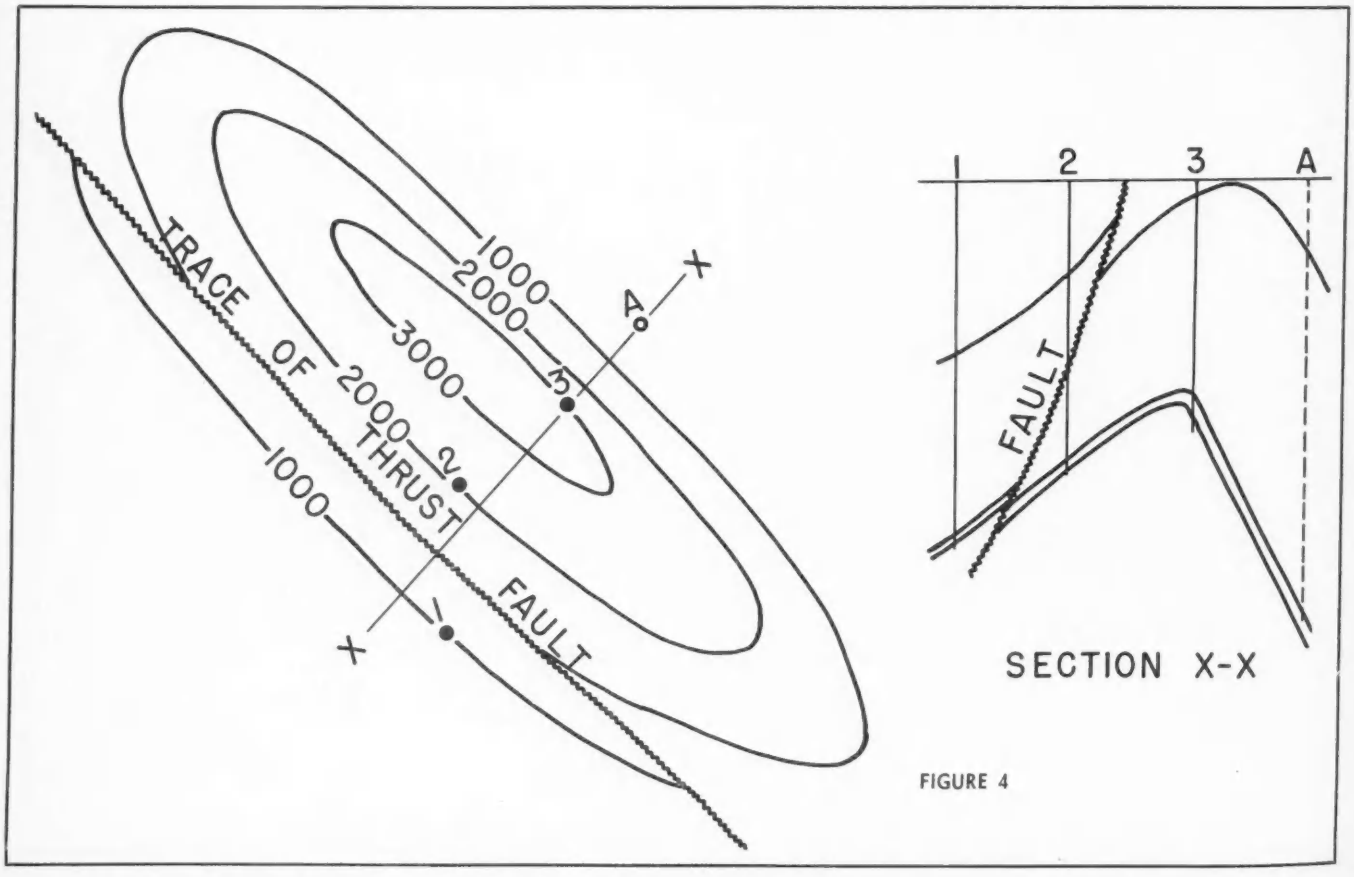
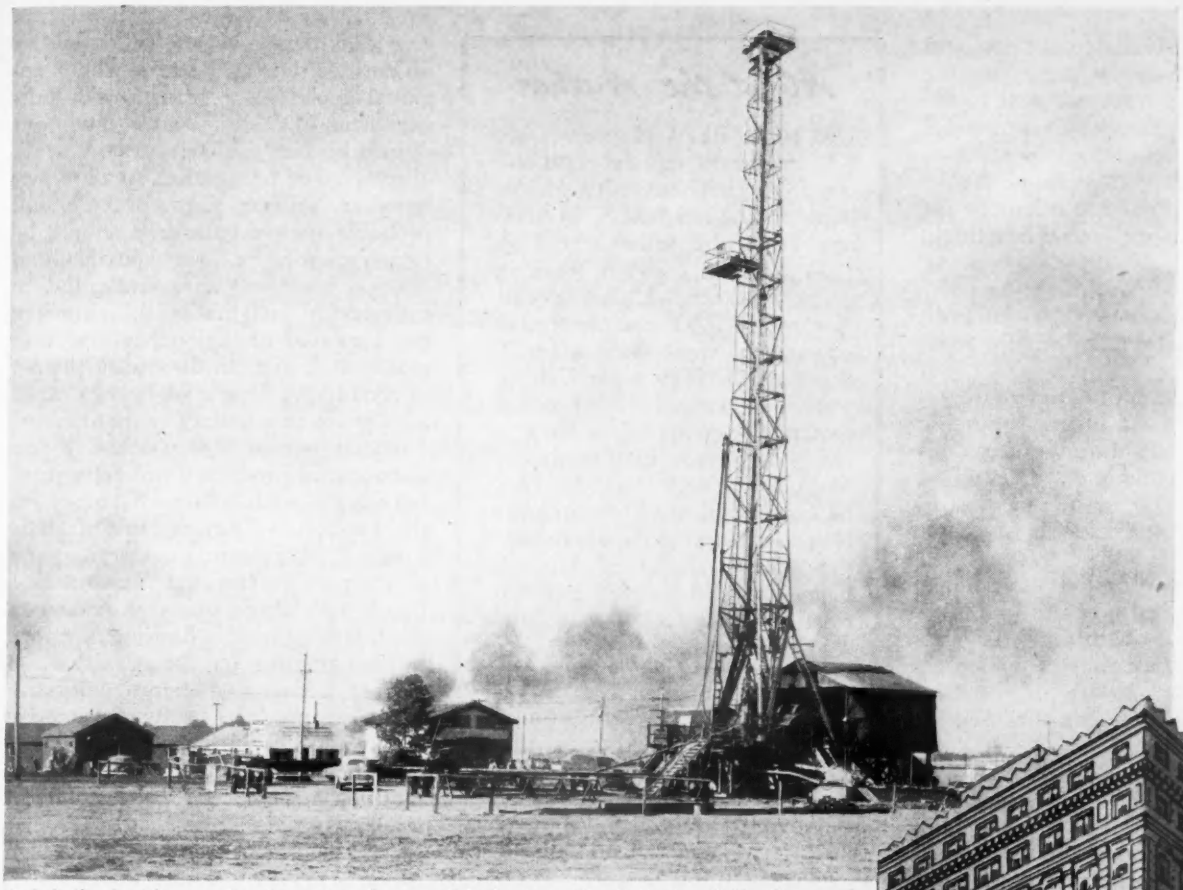
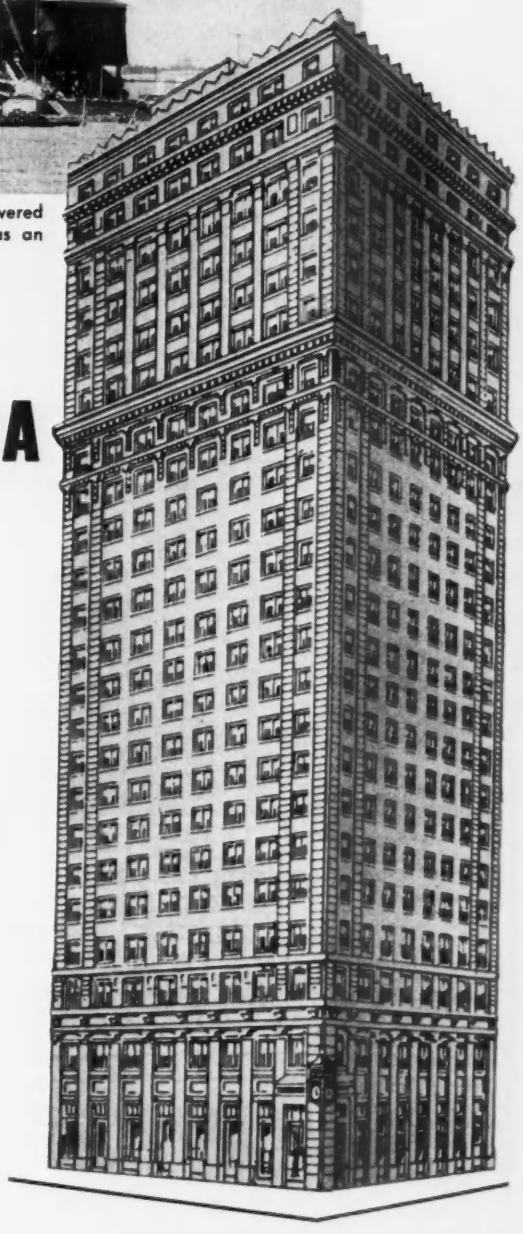


FIGURE 4



Jack knife derrick operating in center of town of Redwater. The Redwater Field, discovered in 1948, is considered Canada's most important. With 674 wells completed, the field has an estimated recoverable reserve of 500 million barrels. Photo by H. Pollard.



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even if all were available, the geologist may still be in doubt regarding the true equivalents from one well to another if facies changes are profound. It becomes increasingly important to make use of correlative data that the engineer can provide to augment the other correlation methods. These might include:

- Statistical studies of analyses of formation waters and oil from individual formations in widely separated wells.
- Studies of bottom hole pressure variations as an aid in understanding the regional continuity of porous blanket formations.
- More exhaustive studies of electrologs than most geologists are competent to make.

Imperial Oil Limited at Calgary has already undertaken and acquainted industry with some very valuable studies regarding the water characteristics of several of the Cretaceous and Devonian horizons of Alberta.

The D-1 zone of the Upper Devonian of Central Alberta presents a fine example of a formation that could profitably be studied by combined geological and engineering approaches. This blanket dolomite formation has yielded small amounts of oil at many localities. The gravity of the oil varies markedly from one well to another. Bottom hole pressure reflect in general a depth gradient relationship, but there are abnormalities which are not readily explained. It is most probable that this formation will eventually produce commercially, but it will take careful appraisal of all factors enumerated to result in a predicted discovery.

Finally, it would be well to comment briefly upon the relationship of the geological and engineering points of view in the estimation of potential reserves of petroleum and natural gas over extensive regions. Conservative practice in such appraisals permits consideration of only the reserves that engineers regard as proven or semi-proven. In long-range planning, however, it is the growing tendency to give due regard to the potentialities of entirely untested areas where regional geological considerations indicate structural and stratigraphic conditions of fair similarity to the areas of established production. At all stages, however, proven, semi-proven and probable reserve categories should be clearly defined and segregated. Great caution and restraint is essential in introducing imaginative thinking into the appraisal of regional reserve estimates. It is akin to the use of pepper in cooking. A little is highly desirable; a lot yields an unpalatable monstrosity.

It has not been the intent of this discourse to produce a brochure justifying some such title as "Geology for the Petroleum Engineer in One Easy Lesson." Petroleum engineering and petroleum geology are distinct and highly specialized fields of endeavor. Each is worthy of a lifetime of effort.

The attempt has been, rather, to explore avenues whereby cooperative effort can produce results of economic significance. The suggestion is made that the type of imaginative thinking that characterizes the finest geological work has a very real place in the more precise field of petroleum engineering. At the very least, exploration of another point of view is an absorbing exercise.

About the Author

DR. H. H. BEACH received his B.S. degree in mining engineering from the University of Alberta in 1932, an M.S. in geology from the same school in 1934, and did graduate work in geology at the University of Toronto in 1935, completing his educational work with a Ph.D. degree in geology from Yale in 1940. He was employed as exploration geologist with the Geologic Survey of Canada between 1935 and 1943. In 1943 he joined McColl-Frontenac Company as a geologist, becoming chief geologist of McColl-Frontenac and Texaco Exploration Company in 1948.

ACKNOWLEDGMENT

The writer wishes to thank J. B. Webb, chief geologist, Anglo Canadian Oil Company, Ltd., and Dr. G. M. Furnival, Standard Oil Company of California, both of Calgary, Alberta, and Milan Arthur, reservoir engineer, Union Oil Company of California, Los Angeles, for helpful suggestions in the preparation of this paper.

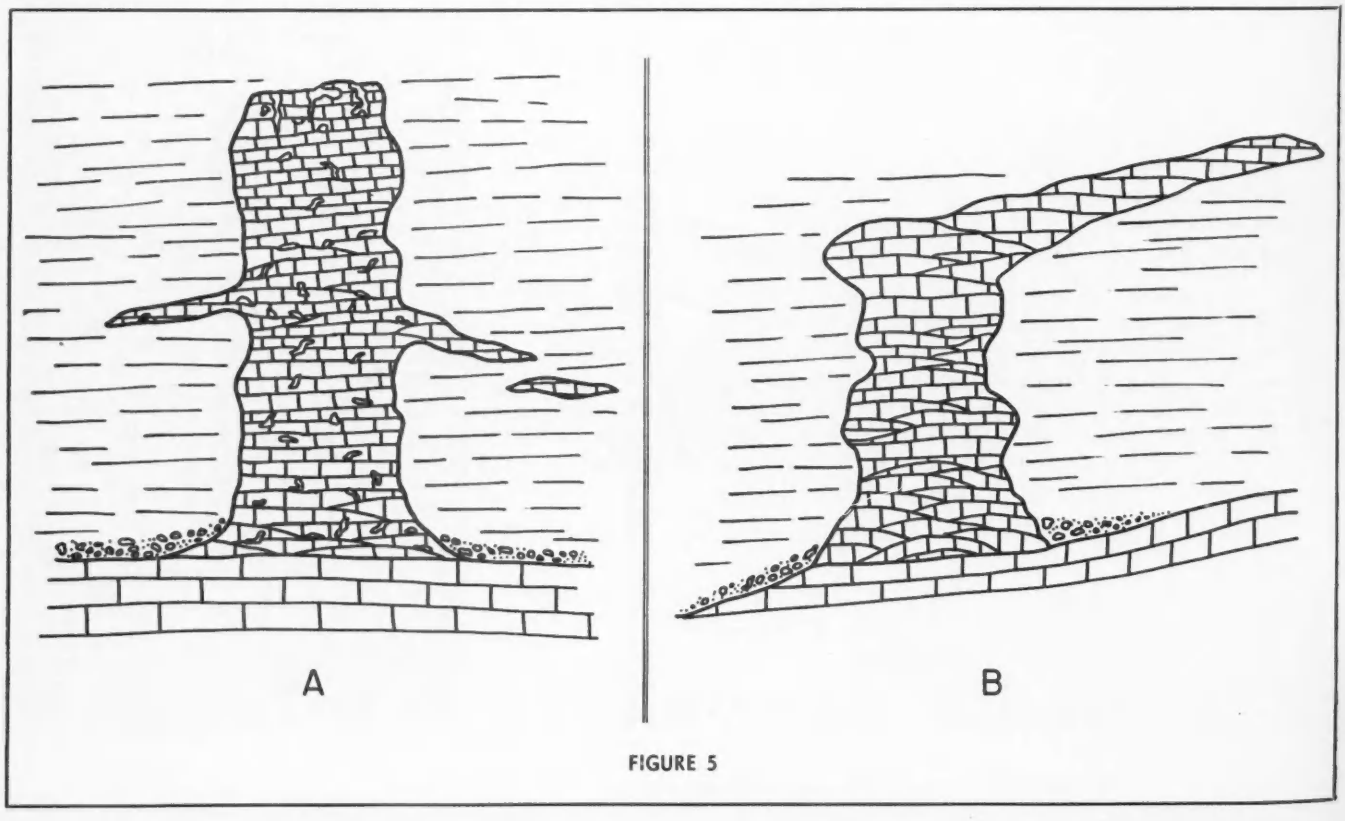

FIGURE 5

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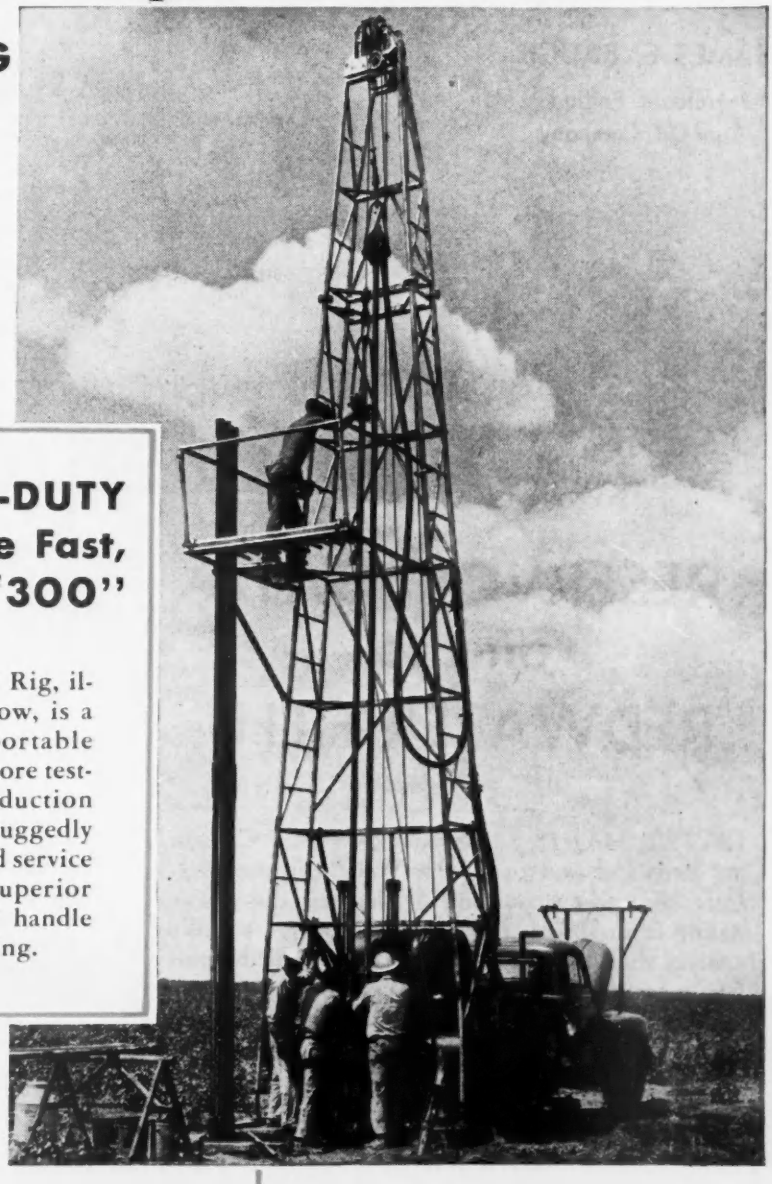

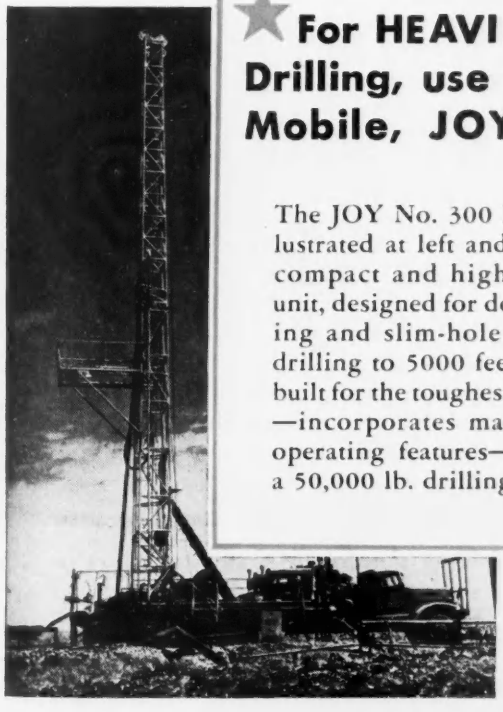

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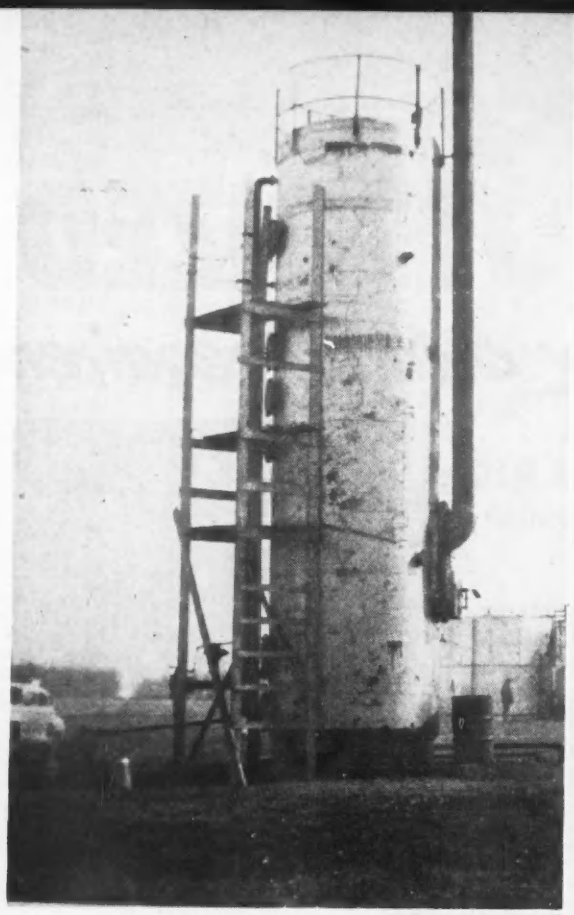

RESERVOIR DATA on the REDWATER FIELD

OF THE MAJOR oil producing fields in Canada the Redwater and the Leduc-Woodbend are presently the most important. With their discoveries dating from 1947 it has not been possible to fully analyze their reservoir characteristics until the past few months. The information gained from these studies will be presented in a series of three articles beginning in this issue with the Redwater field, and followed by the Leduc D-2 and D-3 oil pools.

INSET. Heater-treater in Redwater

RIGHT. Jackknife rig drilling in Redwater field.

THE Redwater field was discovered in September, 1948, by Imperial Oil Limited when Imperial Redwater 1 obtained a flow of light oil at about 3200 feet, from the Devonian D-3 zone which had been proven productive for the first time by the discovery of the Leduc field in 1947. Since that time, the development at Redwater has been rapid and the Redwater field is recognized as Alberta's largest single reserve, despite the fact that the productive area is not yet completely delineated.

Since the field is less than 40 percent drilled out and the cumulative production from the field amounts only to a small percentage of the recoverable oil in place, a comprehensive reservoir study to evaluate percent recovery, rate of water influx, and so on is not possible at this point. However, there has been a considerable amount of data obtained and the production characteristics are fairly well understood.

Figure 1 is a type log section of the geological formations* encountered in Redwater wells. The Devonian in this area contains three main porous zones designated D-1, D-2 and D-3 from the uppermost to the lower zone. While the D-1 and D-2 have been productive in other parts of the Province, the D-3 is the sole productive zone in the Redwater field. The D-1 has been exposed to severe erosion during Devonian time and consequently has a very irregular surface as indicated in Figure 4. In some places the entire D-1 and D-2 sections have been eroded away. Where porous D-1 and D-2 zones are present in the Redwater field, they have been found to be water-bearing.

The D-3 zone structure is recognized as a local high or a large coral-

* The Alberta Association of Petroleum Geologists has recently accepted a different nomenclature for the various formations and members shown on the type log. However, this is not yet well known so the original nomenclature has been used throughout this paper.

type reef. The overlying rock, named the green shale, forms a hard impervious cap-rock for the pool. In areas where the D-3 reef is not present the green shale thickens from 150 feet over the reef to several hundred feet beyond the edge of the reef.

The present producing portion of the pool is not yet fully developed. The extent of the pool to the southeast and northwest directions is not yet known. Imperial Simmons 1 in Legal Subdivision 1, Sec. 25, Township 56, Range 21, west of the fourth meridian, is located on one of the highest points on the reef structure and the pool may extend for some considerable distance beyond this well in a southeast direction.

The oil-bearing section of the reef has a maximum thickness of about 200 feet. The oil zone is underlain by an aquifer or water body of undetermined thickness, possibly 800 to 1000 feet. This water-bearing section of the reef has been encountered in several wildcat wells west and northwest of the producing area of the Redwater field. The water-level in the pool appears to be uniform and continuous and occurs at a depth of 1238 feet subsea.

Reservoir Rock Properties

The D-3 reef at Redwater is made up of a light brown to cream colored limestone with little or no dolomitization present. Core analyses indicate the average porosity of the rock above the water line to be 8 percent. However, there is extreme variation from well to well (and in any one well) in the nature and degree of porosity. A few wells have indicated average porosity in the D-3 to be in excess of 15 percent and in others as low as 3-4 percent.

There exists a tight section on the top of the D-3 up to 40 feet in thickness of practically zero porosity. This condition reaches a maximum on the flanks of the pool, generally outside the 1200 foot subsea contour. Some wells located high on the reef encounter little or no tight cap rock and it is in such wells that the highest average porosity in the porous section is found. The minimum, maximum and average figures mentioned above refer to the total D-3 section including any tight zone on top of the reef.

Porosity occurs both as large vugs and fine intergranular voids. The presence of the vugs generally characterizes the zones of best porosity and permeability, the latter varying from zero to infinitely large values as determined by core analyses. The extremely good permeability is attributed mostly to the vuggy nature of porosity although

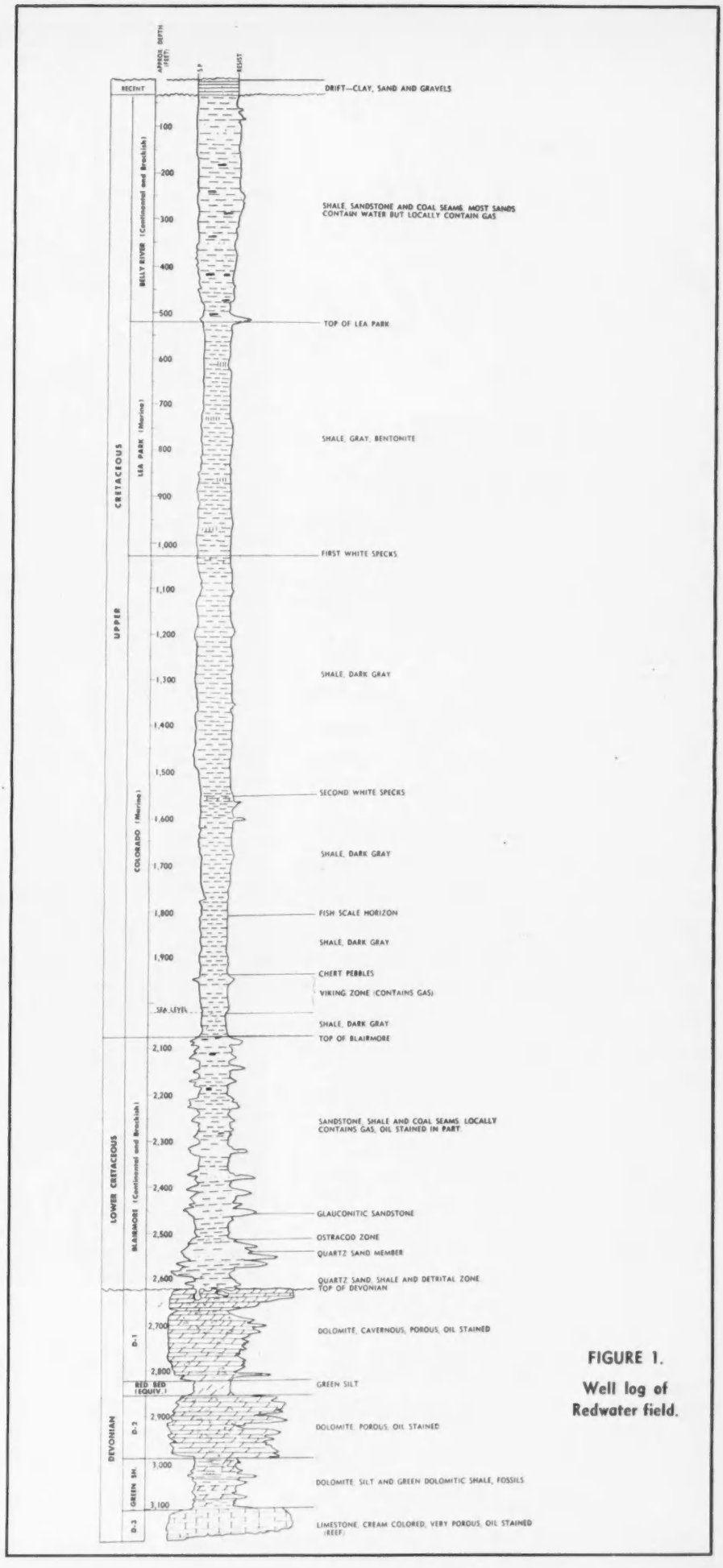

FIGURE 1.

Well log of Redwater field.

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severe fracturing has been observed on some cores, which may be responsible in part for this properity. From observation of a number of core analyses on several wells, on the average, about 30 percent of the cored sections have a permeability greater than 100 millidarcys. In many cases these high values are unmeasurable on a core since a vug or fracture may pass through the core resulting in an infinite permeability reading on the permeameter. The table of reservoir data includes a summary of these properties.

Reservoir Fluid Properties

The reservoir fluid in the Redwater field originally existed at 1050 pounds per square inch gauge and 94° F. The crude, averaging 35.5 stock tank gravity, was undersaturated, the bubble point being 485 psig. The solution gas-oil ratio as determined by differential liberation on a subsurface sample was 180 cubic feet per barrel on a residual oil basis and 161 cubic feet per barrel on a reservoir fluid basis. The viscosity of the reservoir fluid at 94° F. is 2.9 centipoises.

Redwater crude is fairly high in sulfur and chloride content, the total sulfur in the crude being 0.5-1.0 percent. The hydrogen sulfide content of the gas is about 3.5 percent. Water soluble chlorides in the crude average about 100 pounds per 1000 barrels.

The shrinkage factor of the reservoir fluid from reservoir conditions to stock tank oil as determined by differential gas liberation is 0.88.

The excellent reservoir rock permeability as discussed above is further shown by the high productivity index values for Redwater wells. Extensive flowing bottom hole pressure surveys indicate productivity indices of wells

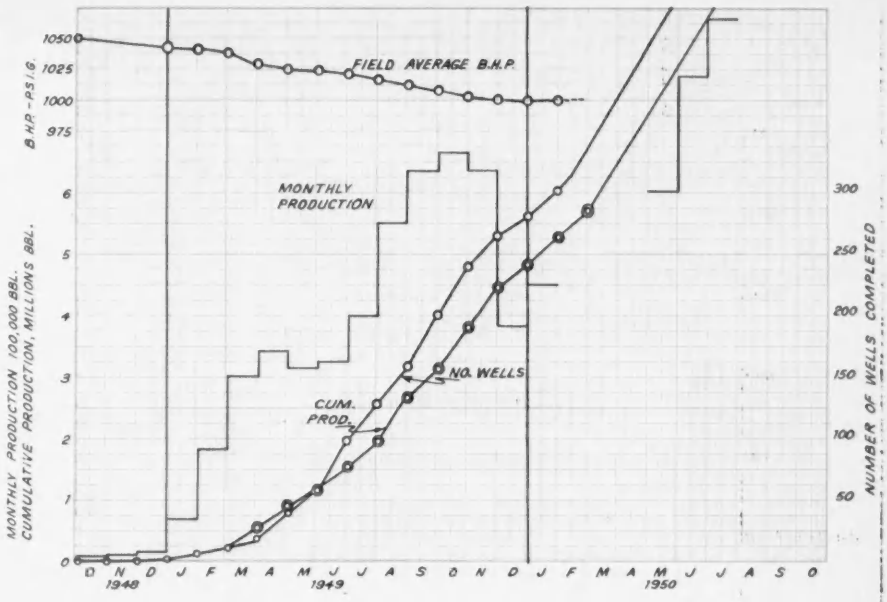

FIGURE 2. Reservoir history of Redwater field.

to be about 120 barrels per day per pound pressure drop on the average, and some values as high as 400 have been recorded. There seems to be very little correlation between structural location and productivity index. However, accurate determination of such a relation has been hampered by the fact that even at high flow rates the flowing bottom hole pressure is only a few pounds per square inch below static pressure, approaching the precision of the pressure gauges in use. Specific productivity indices average about 1.5 per net effective foot.

Extensive studies of productivity indices have been made by several companies operating in the Redwater field for the purpose of evaluating the effectiveness of acidizing. In most cases the productivity index of a well is doubled by selective acidizing of the zones of lowest porosity and permeability.

Production History

Figure 2 is a graph of the production characteristics of the Redwater Pool showing the number of wells completed, the production and field average bottom hole pressure decline since the discovery of the pool. The cumulative average measured gas-oil ratio has been very constant at a value of about 150 cubic feet per barrel due to the low degree of saturation of the reservoir fluid.

The behavior of the field average bottom hole pressure curve indicates the presence of at least a partial water drive. There has been little or no decline in the field pressure since November 1949, which relates to the curtailed production rates during the succeeding months. This is also shown on Figure 3 on which average pressure is related to cumulative production.

The average pressure values were calculated from a large number of individual well bottom hole pressure tests and graphically averaged to obtain the points shown. Pressure equalization across the reservoir is rapid and uniform since individual wells vary from the average by only about plus or minus six pounds per square inch.

Due to the low degree of gas saturation in the Redwater reservoir, the flowing life of the wells is expected to be relatively short. In this connection, many wells are being completed with pumping equipment and other wells are installing pumps to be used at present only to agitate or swab the wells into a flowing condition.

As of August 1, 1950, the Redwater pool had produced 9,644,959 barrels

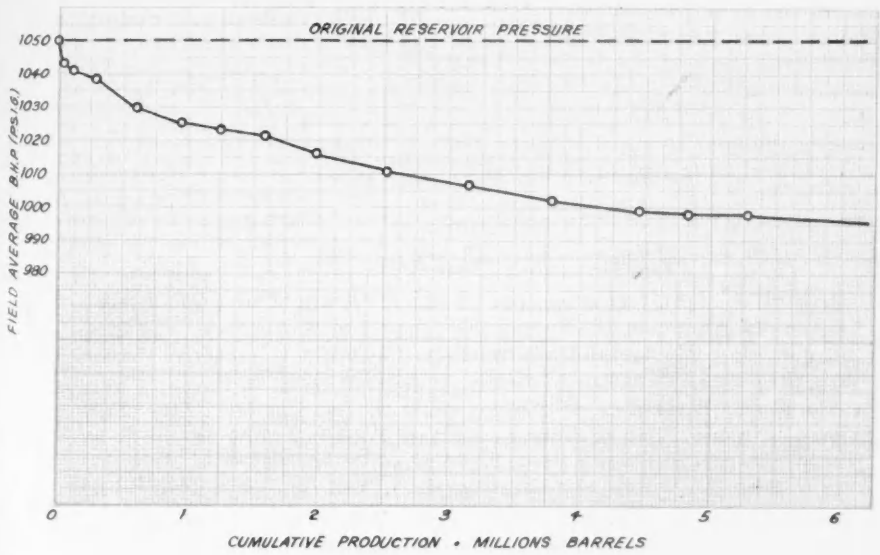

FIGURE 3. Pressure decline with production, Redwater field.

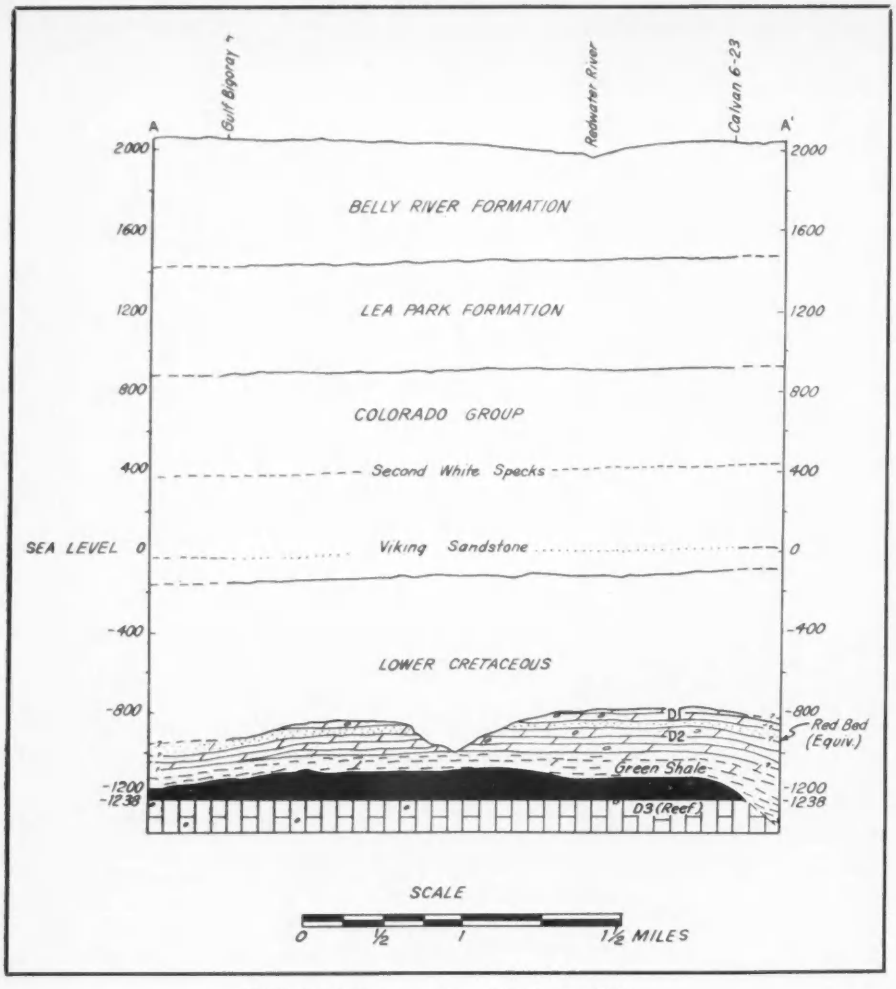

FIGURE 4. Cross-section of Redwater field.

and the reservoir pressure decline accompanying this production was 102 pounds (from 1050 to 948).

The table of reservoir data shows 490 barrels of stock tank oil in place per acre foot as calculated from the average porosity, connate water content and shrinkage outlined in the same table. In view of the wide variation in porosity from one part of the field to another this figure will also be greatly different from well to well. Assuming the water drive to be fairly active and effective throughout the life of the field, preliminary estimates indicate that the oil recovery will be 200 barrels per acre foot based on the average conditions above. Various estimates of the productive area and volume of the pool have yielded total recoverable reserve figures in excess of 500 million barrels. Further production history will permit the accumulation of data required in a material balance type of calculation to substantiate or replace this volumetric type of calculation.

Reservoir Data

GENERAL DATA	Value
Depth of wells (average), ft.	3,200
Thickness of porosity above water (maximum), ft.	200
Ground elevation above sea level (average), ft.	2,050
Depth of water table, subsea, ft.	1,238
RESERVOIR FLUID PROPERTIES	
Reservoir pressure (original), psig.	1,050
Reservoir pressure (present), psig.	998
Reservoir temperature, °F.	94
Solution gas-oil ratio, original (reservoir fluid basis*), SCF/bbl.	161
Solution gas-oil ratio, original (residual oil basis*), SCF/bbl.	180
Shrinkage factor, from virgin conditions to 14.4 psia. and 60° F., vol./vol.	0.88
Gravity of residual oil, A.P.I.	35.5
Compressibility of saturated reservoir fluid at 94° F., percent per 1000 psi.	0.65
Thermal expansion of reservoir fluid (from 75° F.-110° F.), percent per °F.	0.050
RESERVOIR ROCK PROPERTIES	
Porosity, bulk volume basis (average), percent	11
Connate water content (average), percent	12
Permeability; range, md.	0-infinite
Permeability; average percent of cores having permeability greater than 100 md., percent	30
VOLUMETRIC ESTIMATE	
Volume of oil in place per acre-foot (estimated), bbl.	490

Note: Bottom hole pressure datum is 1165 feet subsea.
* Based on differential liberation.

General Practices

Generally, drilling conditions in the Redwater field are very good. This fact, combined with the shallow depth of production, tends to allow rapid well completions and development of the field as a whole. Average completion time is about 25 days and actual drilling time is as low as five days. Several instances of lost circulation and temporary loss of control have been encountered in the porous, water-bearing D-2 zone with gas from the Lower Cretaceous or Viking sands blowing out.

Both open-hole and perforated liner completions are practiced in the field, the latter being used to a lesser extent since the liner tends to lower the productivity index of the well. Several of the operators in the field complete their wells only 20 feet into the porous zone regardless of pay thickness. This is to eliminate as far as possible the tendency for water to cone into the wells from the water table.

There are currently approximately ten wells producing water in excess of 1 percent in the field. These wells are either structurally low or have been completed within about ten feet of the water table. The total water production is very small at this time, but it is expected to be a major problem in the future. Plans are being formulated among the operating companies to design and construct a salt water gathering and disposal system.

Diamond coring has been carried out very extensively in the field. Also radioactivity logs, electric logs and micro-logs are being run to determine as much reservoir information as possible.

ACKNOWLEDGMENT

The author wishes to express appreciation to the Petroleum and Natural Gas Conservation Board of Alberta for making this information available for publication; also to the companies operating Redwater wells, especially Imperial Oil Limited for core analyses and reservoir fluid information.

About the Author

JAMES E. BAUGH was graduated from the University of Alberta in 1946 with a B. S. degree in chemical engineering. He worked for the Dow Chemical Company of Canada at Sarnia, did geological work in the MacKenzie River area on the Canol project, worked on gravity meter surveys on the southern Alberta plains for California Standard Company, Ltd., and was engaged in reservoir engineering work for the Petroleum and Natural Gas Conservation Board of Alberta at the time he wote this article. At present he is employed by the Sun Oil Company of Canada as petroleum engineer.

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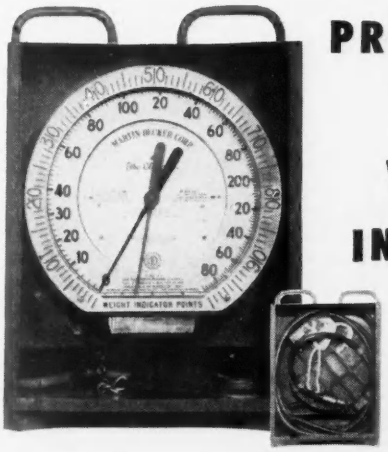

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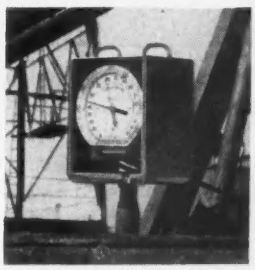
- ELIMINATES EFFECT OF DEAD LINE WHIP
- LASTS LONGER



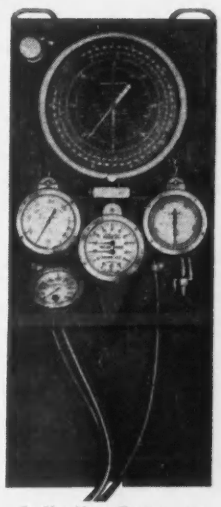
A Portable Model Clipper "Sealtite" installed on Ideco H-40 rig. Portable models are ideal for any small space

The Portable Model Clipper "Sealtite" is so light and compact that it can easily be moved. Note convenience of handles.

For MILLING, CUTTING JOBS and DIAMOND CORING

the Streamlined Martin-Decker HYDRO-MECH TORQUE GAUGE

INCREASES FOOTAGE when drilling with small bits
SAVES CHAIN
INCREASES FOOTAGE on deep wells



Indicating Gauge can be installed as an individual unit or as an integral part of other Martin-Decker Controls.

The Martin-Decker Hydro-Mech Torque Gauge gives the driller a rugged, dependable instrument for indicating torque in the drill pipe. It instantaneously measures either the total torque or net-torque-on-bit at the driller's position.

The assembly consists of a load-sensitive element—chain idler, load-responsive cylinder, high-pressure hose, damper and 6-inch "rotate-able" dial indicating gauge. The idler wheel is pushed (chain thrust) by the tight side of the rotary chain. The push is directly related to the torque in the drill pipe; the higher the torque—the tighter the chain. The load-sensitive element, connected to the same lever arm as the idler wheel, builds up a hydraulic pressure to oppose the chain push. This pressure is used to actuate the dial gauge at the driller's position, indicating the instantaneous torque in the drill pipe.

- FOR ALL RIGS WITH CHAIN-DRIVE ROTARIES
- THE TORQUE GAUGE THAT OPERATES WITH DIESELS
- CAN BE SET FOR NET-TORQUE-ON-BOTTOM WITH "ROTATE-ABLE" DIAL
- A SIMPLE INSTRUMENT OF REMARKABLE SENSITIVITY
- EASY TO READ AND UNDERSTAND

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Diamond Coring in Western Canada

By J. F. LANGSTON

Managing Director, Denton-Spencer Company, Ltd.,

Consultants

This illustrates length and continuity of diamond-cut cores.

DIAMOND coring, as presently applied in the oil field, is considered to have started in 1945 in West Edmond field in Oklahoma. The results in the first few wells warranted further trials, and development of specialized equipment for use with rotary rigs was rapid.

Subsequently, in the hard Weber sand at Rangely, Colorado, diamond coring proved to be cheaper than drilling with rock bits. This allowed for refinements to be made in equipment, and for experimentation in methods. The equipment originally taken to Rangely was quite adequate for the job, but as considerable more coring was done, and as coring equipment was handled by newly trained personnel, certain difficulties arose.

Diamond core drilling was developed originally by Rudolph Lescheot in 1863 to drill blast holes during the construction of the Mont Cenis tunnel between France and Italy. It was gradually developed for use in the mining fields.

Although it is stated above that coring with diamonds in the oil field is considered to have started in 1945, it is well known to anyone who grew up near Turner Valley that naphtha wells were drilled-in during the 1920's with diamond coring equipment. This coring was done using hydraulic chucks and drilling equipment designed for the work. Similarly in 1940, two Pacific Petroleum Company wells in Turner Valley were cored in the Madison limestone using bits and equipment which were not too greatly different in general design from the presently used equipment.

There have also been several uses made of diamond core drills in the smaller size to drill wells for oil in the foothills of Alberta, and in the Flathead River Valley of British Columbia. The equipment used, however, was necessarily adapted from hard rock mining equipment, and would not lend itself to use on the regular rotary rig.

Another illustration of the size of the cores.

DIAMOND CORING as it is now practiced in Western Canada has been found to be less costly than the conventional method of coring. One reason for this is that rig time is reduced by the faster penetration of the diamond core head in the hard limestone formations, and greater recoveries of the vuggy reef formations are possible for reservoir studies.

The first use of diamond coring in its modern form in Alberta was in January, 1947, when Royalite Oil Company Limited's Foothills 25 was cored. Results were fair, but due to loose chert, two diamond core-heads failed. The third, however, cored 88 feet in this well, and was still in very good shape at the end of the well. The average recovery of core was 90.4 percent.

The introduction of diamond coring in the Leduc field, to core the Devonian zones, took place in the early stages of development of that field. The British-American Oil Company's Pyrcz 1 was cored in the spring of 1947, and 445 feet were cut, with a recovery of 97 percent made up from the D1, D2, Green Shale, and D3 zones.

The necessity of obtaining accurate reservoir information in the early stages of the development of the Leduc field made it imperative to get the high recoveries allowed by diamond coring for core analysis. It was found, however, that the taking of the small plugs normally used in core analysis from the large cores could not allow for accurate evaluation. Sometimes the vugs were large enough that the normal-sized plug could be lost in them; therefore, the new technique of using the full core in the laboratory was developed.

Diamond coring is now generally applied in all limestone zones in Canada in order to obtain a high percentage recovery, and also because it has proven cheaper in the per footage cost of coring.

Second core tray from the bottom shows hard, compact limestone section (about six inches) in the center of the tray, just above the "bleeding" (dark) portion at the bottom.

Pulling a diamond core barrel in mid-winter operations.

Core barrels generally used will take a 50-foot core. The hole size is 6⅛ inches and the diameter of the core is 3½ inches. It is quite regular practice to cut 50-foot cores.

Essentially the requirements of the equipment to get good recovery are smooth cutting, a non-rotating inner barrel, and a design to facilitate the entry of fractured cores into the barrel without jamming.

These requirements are met in the diamond core barrel. The bit cuts the formation by abrasion, not by the chiselling or chipping action of the rock bit. The inner barrel is suspended from a bearing assembly which is grease lubricated. The inner barrel on its lower end contains the core catcher and the lower end of the inner barrel is placed very close to the bit to allow the best conditions for the undisturbed entry of the core.

It is essential that the hole should be free of iron, which will cause the failure of a diamond bit. Bit teeth, tong dies, and roller bearings from bit cones often remain in the hole during normal drilling operations with rock bits. Sometimes small pieces of steel become imbedded in the walls of the hole, and may fall to bottom during coring operations. Every effort is made to avoid the damage of bits by steel. The precautions are simple. Good care of the hole which is scheduled to be diamond-cored can be maintained. Tong dies are kept keyed in place. If the cones are lost from a bit, they are fished out with a junk basket. A junk sub is run on the last two or three rock bit runs before diamond coring. Also, there are junk grooves in the side of the bits so that small pieces of iron can be circulated away from the bottom of the hole after cutting to bottom.

The operation of the diamond core barrel is not at all mysterious, but it does require definite attention to detail. It is not at all unusual to find the regular rotary drilling crews running the core barrels without any special supervision, after once being trained. No difficulty is encountered as long as correct procedure is followed. Many companies run their own core barrels on contract rigs, and supply their own supervision through an engineer or toolpusher. The diamond coring companies also have supervisors to run diamond coring equipment owned by the well owner, or will supply rental barrels which may be run by the well owner's engineer or by the diamond coring company's own supervisor.

It is more economical for a company to have its own equipment and supervise its own operations if enough coring is to be done by that company. A small company finds it expedient to rent equipment and hire supervision services as required on a particular job.

The equipment was designed so that any rotary rig with standard equipment can be used. A weight indicator and mud pump gauge in good condition are required. It is necessary to be able to throttle the pumps down to circulate about 150-200 gallons per minute. It must be possible to adjust the rotary speed in the range 60-90

revolutions per minute. A good brake which will allow steady "feeding-off" is a distinct advantage. All of these conditions are found on the average rigs in Alberta.

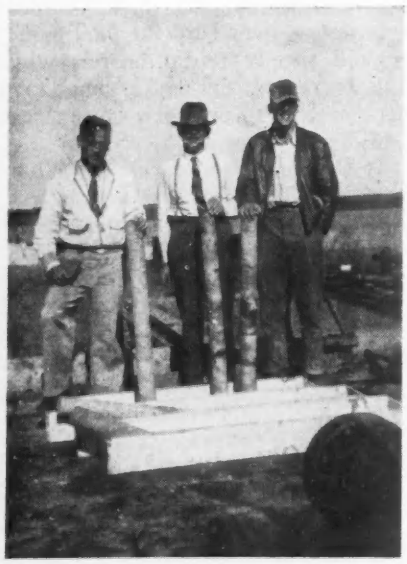
The condition of the drilling mud affects diamond coring. The speed of penetration is normally increased with lower viscosity, but high viscosity muds do not prevent diamond coring. The ideal fluid for diamond coring would be water.

The volume of fluid circulated is a critical factor. It is necessary to have sufficient fluid to properly cool the bit without causing erosion of the bit matrix. The sand content of the mud naturally affects the amount of erosion. Normally quite large fluid volume of the order of 1/3 to ½ of the volume used while drilling can be maintained. This less-than-normal fluid volume has never shown any effect on subsequent hole conditions.

During coring operations, the fluid volume is regulated by maintaining the pump strokes at a constant figure to deliver a pre-determined volume. The pump pressure is noted both before and after the bit is put on bottom, and it is considered that a pressure increase for the same fluid volume, of 150-200 pounds per square inch should be obtained when the bit is on bottom. A greater pressure differential would probably cause fluid erosion, and a lesser volume might not cool the bit.

The pump pressure is watched during the coring operation, and is indicative of a bit failure. If a bit should lose a ring of diamonds the formation would groove up into the bit sealing off the water courses and thus causing a greater pressure differential than normal. Under such circumstances the bit would be withdrawn from the hole before more diamonds were lost.

The amount of weight on bottom is closely regulated, and it is usually found that under any specific conditions there is a certain weight on the bit which gives best results. Excess weight causes the bit to bury itself. Lack of weight keeps the bit from working. In the D2 and D3 formations, it is normally found that 3000-5000 pounds of weight on bottom are most effective.



This photo shows size of cores available with diamond core barrels.

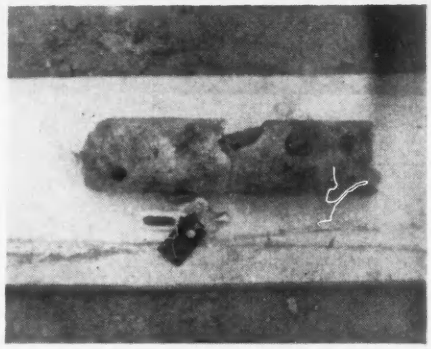
Coring Cost

The cost of diamond coring is considered to be less than that of any other type. This applies in Alberta to the limestone, hard sands of the Lower Cretaceous, and so on. The faster drilling time in the D2 saves considerable rig time. A 50-foot core was taken on Imperial Woodbend 25 in six hours time on bottom. Also bit footages have steadily increased until now 800-1000 feet of coring in D2 and D3 zones is not an unusual performance for a bit.

The diamond bits first introduced into the Canadian oil field scene with this equipment, were made by Wheel Trueing Tool Company of Canada Limited. These bits are manufactured in Canada by this subsidiary of the American company supplying them to the oil fields there. There are now one or more other companies making similar diamond bids in Canada, but bits are being imported from the U. S. by the other companies in the field. These imported bits have been allowed duty free entry as oil field equipment.

The bits have a salvage value of from 40-60 percent of the diamonds after use. This materially decreases the actual cost of the bit which has to be charged to a job.

In some areas of the U. S., such as Rangely, Colorado, it has been found that the use of diamonds has allowed the penetration of very hard formations at a lower cost than by drilling with a rock bit. It is believed that this same condition exists in areas of northeastern British Columbia, where the Triassic siltstone is encountered. The high cost of drilling this formation with rock bits can be materially reduced by coring with a large-diameter diamond core barrel, using 8½- or 9-inch core head size.



This diamond core shows the large vugs in the limestone reef formations. Key chain at bottom shows size of core and vugs.

The initiation of diamond coring into the oil fields was carried out to obtain high recoveries in formations where other equipment could not obtain them. Undoubtedly a considerably higher cost could be justified as long as the objective of high recovery was obtained. However, it has been found that diamond coring, while giving very close to 100 percent recovery, is as cheap or cheaper in its over-all cost, as any other method.

ACKNOWLEDGMENT

It is the writer's wish to acknowledge information made available to him by Carroll Deely, of Drilling & Service, Inc., Dallas, and information obtained by the diamond coring staff of Denton-Spencer Company, Ltd., on coring jobs for various companies in western Canada.

About the Author

J. F. LANGSTON was graduated from the University of Alberta in 1937 with a B.S. degree in engineering. After a year with Calgary Power Company as apprentice engineer, he joined Lane-Wells Company as field engineer in Turner Valley. In 1941, he joined Denton and Spencer, consultants, in the capacity of petroleum engineer and became managing director of that firm in 1945 when it was reorganized into Denton-Spencer Company, Ltd. In addition to his work as director, he does consulting work in petroleum engineering and operates a diamond coring service. Langston is vice president of the Oilfield Technical Society, a member of several professional engineering societies in Canada, a member of AIME and the Alberta Society of Petroleum Geologists.

Significance of

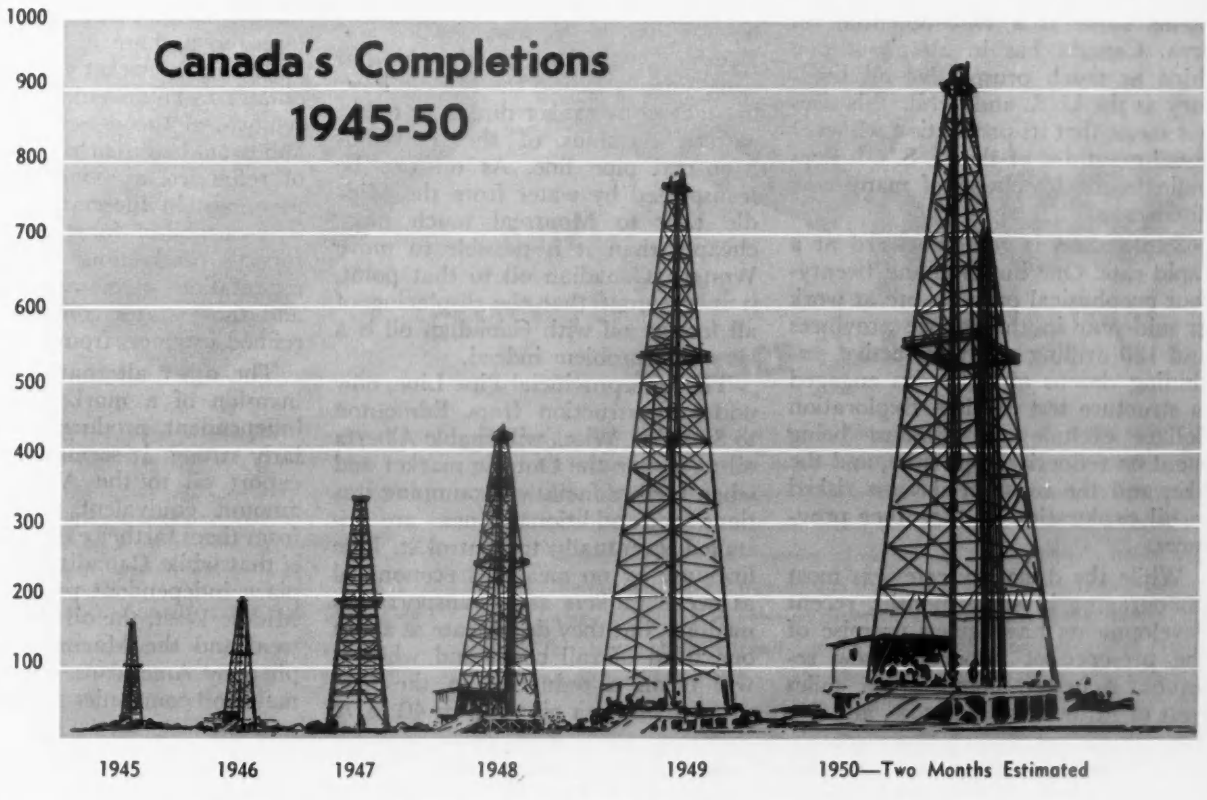
Canada's Oil Resources

By G. W. AUXIER
Executive Vice President
Western Canada Petroleum Association

MOST of the oil used in Canada has to be imported. In 1949, of a total crude consumption of 98 million barrels, about 22 million came from Canadian sources, 29½ million from the U. S., and 46½ million from other sources, mostly Venezuela but some from Arabia, Trinidad, and Iraq. Canadian production was up about 10 million barrels from 1948, but total consumption increased by well over 8 million, so net reduction in imports was not nearly so great as might be assumed from production figures. As a matter of fact, 1949 was the first year since 1941 that showed any drop in imports. Imports had been climbing annually from 44 million barrels in 1942 to 77 million barrels in 1948, due to rapid increase in consumption.

As Canada's whole way of life is based largely on petroleum and petroleum products, as oil is the largest single import item, and as most of it has to be paid for in dollars, it is almost impossible to overestimate the importance to Canada of finding its own oil supply.

So far, the Canadian oil industry is in its infancy. On June 30 of this year in Alberta, 1574 wells were capable of producing oil plus 150 or so in Saskatchewan and some in the Northwest Territories, New Brunswick, and Ontario. In 1950, to date, about 10,000 feet of hole per day has been drilled. Canada's daily production averaged about 64,000 barrels daily for the first half of the year, and during the recent summer period, consumption reached a record high for one week of 86,000 barrels daily. Existing wells are capable, within limits set by good conservation practice, of pro-



Wells Completed and Footage Drilled in Western Canada

Field and Province	1945		1946		1947		1948		1949		1950 (10 Months)	
	Wells	Footage	Wells	Footage	Wells	Footage	Wells	Footage	Wells	Footage	Wells	Footage
Leduc-Woodbend	....	.....	....	.....	37	236,884	147	901,406	200	1,058,562	143	752,309
Redwater	....	.....	....	.....	....	.....	3	12,361	300	979,323	412	1,336,661
Turner Valley	16	129,465	13	113,810	7	83,205	7	69,914	6	51,493	4	33,959
Other Fields	108	354,548	115	372,847	151	535,682	197	665,998	207	916,915	249	1,119,882
Total Alberta	124	484,013	128	486,657	195	855,771	354	1,649,679	713	3,006,293	808	3,242,811
Saskatchewan	20	60,130	54	116,540	119	223,006	70	137,389	51	100,030	11	41,626
Total Western Canada	144	544,143	182	603,197	314	1,078,777	424	1,787,068	764	3,106,323	819	3,284,437

duction of about 150,000 barrels daily.

By way of comparison in the U. S., in the first half of 1950, drilling averaged 411,000 feet per day. Daily average production was more than 5.5 million barrels daily, and the potential was well over 6 million barrels. In fact, actual daily production reached well over 6 million barrels in August. Texas daily production currently exceeds 2.3 million barrels per day, and Illinois, Kansas, Louisiana, Mississippi, New Mexico, Oklahoma and Wyoming each produce a great deal more oil than does all of Canada. In rates of drilling and in potential production, American figures are 40 to 41 times as great as Canada's.

Nor does it appear that the U. S. oil reserves are diminishing. On the contrary, they are increasing every year. The sensational Scurry County discovery in Texas added an estimated billion barrels to U. S. reserves, mostly in 1949 and this is about the same as the total Canadian reserves thus far proven.

In the North American oil picture, Canadian figures do not seem very large. Nevertheless, the Western plains alone is a vast potential oil area. Canada has in all about one third as much prospective oil territory as the U. S. and, while this does not mean that its production will ever equal one third of the U. S.'s, it does indicate the likelihood of many new discoveries.

Exploration is going forward at a rapid rate. One hundred and twenty-four geophysical parties were at work at mid-year in the prairie provinces and 120 drilling rigs were active, excluding dozens of light rigs engaged in structure test drilling. Exploration dollars exclude the millions being spent on refineries, pipe lines, and the like, and the substantial sums risked in oil exploration in the other provinces.

While the discovery rate was most discouraging in early months, recent developments have given promise of the presence of important new reserves. Acheson, about seven miles west of Edmonton, Camrose, and Big Valley, all in Alberta, are of great importance.

It seems entirely likely that if exploration continues as it has for the past two years, and with the vast area to be explored, many more fields are likely to be found in the future bringing closer the day when Canada's reserves are stepped up from about 1 billion to the 3 billion or so required to make Canada a nation self-sufficient in oil.

Multiple Problem

Finding the oil is, of course, only part of the problem. How to get oil to principal consuming areas at a price competitive with other sources of supply, and still leave a field price sufficiently high to encourage continued exploration, is at least as difficult a problem as finding it.

In 1949, while potential production on the plains was considerably greater than prairie requirements, practically no oil was exported beyond the prairie provinces. That situation holds at present. The Pacific Coast consumes mostly oil from California, much of it in refined form. Ontario consumes oil from the Mid-Continent and Illinois fields of the U. S., and Quebec and Eastern Canada use in the main, oil from Venezuela and the Middle East, brought in by tanker direct, or to the eastern terminus of the Portland-Montreal pipe line. As oil can be transported by water from the Middle East to Montreal much more cheaply than it is possible to move Western Canadian oil to that point, it is apparent that the displacing of all foreign oil with Canadian oil is a very real problem indeed.

The Interprovincial Pipe Line, now under construction from Edmonton to Superior, Wisc., will enable Alberta oil to invade the Ontario market and when further facilities—pumping stations and additional lines—are installed, eventually to control it. Pipe lines are by no means as economical as ocean tankers as a transportation medium, but they do operate at about one third of rail costs, and while it will mean a reduction in the field price of Alberta oil of from 40 to 75 cents per barrel to be on a competitive basis with Mid-Continent American oil, the enlarged outlet will warrant this reduction.

The Ontario market, if and when wholly secured, will absorb about all of Canada's present potential production, but what of the produce of future discoveries? Beyond Ontario the situation becomes more difficult. It is not economically feasible to send Alberta oil to the Montreal market under present circumstances, though completion of the St. Lawrence seaway enabling big tankers to move directly from Superior to Montreal might alter the situation.

This leaves two alternatives, both of which involve the sale of oil to the U. S. These are the Pacific Coast and the Middle West area—Chicago and Minneapolis and St. Paul. The Rocky Mountains are a formidable barrier to the former. Rail costs are too high to make that means of transport feasible. A pipe line could be built, but it would be economical only if a substantial volume of throughput were obtained—something like 60 to 100 thousand barrels daily. The Canadian market on the Pacific is only half that large, so a share of the Washington and Oregon market would have to be obtained. This would necessitate the removal of the present tariff barrier, and would also involve the building of refineries, as none of importance now exist in those states. While this is a possibility for the future, California's production, contrary to the expectations of many, continues high and those states continue to import refined products from California.

The other alternative involves the invasion of a market in which the independent producers are particularly strong. It seems entirely fair to export oil to the Americans to an amount equivalent to that bought from them farther east. The difficulty is that while Canadian oil would displace independent production in the Middle West, the oil bought in Montreal and the Maritimes, while supplied by Americans, comes from the major oil companies and from foreign sources.

These are some of the marketing problems on the horizon. They are engaging the attention of almost everyone in industry, and many in government, and they will be solved. It is apparent, however, that they will be solved only at the expense of some reductions in the field price of oil, for oil prices must be competitive in the areas sought to be served, and transportation costs must be borne out of those competitive prices. This will, of course, mean lower prices for refined

Wells Drilled in Western Canada During First Ten Months of 1950

FIELD	Oil		Gas		Dry		Total Wells		Footage		Rigs Running End of Period	
	1949	1950	1949	1950	1949	1950	1949	1950	1949	1950	1949	1950
Leduc-Woodbend	158	127	...	...	16	16	174	143	922,209	752,309	15	38
Redwater	230	402	2	...	6	10	238	412	776,108	1,336,661	15	15
Turner Valley	6	2	...	1	...	1	6	4	51,493	33,959	2	...
Other Fields	31	81	17	30	127	138	175	249	760,343	1,119,882	36	69
Total Alberta	425	612	19	31	149	165	593	808	2,510,153	3,242,811	68	122
Saskatchewan	37	...	...	...	14	11	51	11	100,030	41,626	...	9
Total W. Canada	462	612	19	31	163	176	644	819	2,610,183	3,284,437	68	131

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products in the producing areas and should stimulate consumption there. This, in turn, will help the development of those areas, but the price cannot in the national interest be permitted to drop so low as to discourage the continued search for the new reserves necessary to meet and continue to meet Canada's total requirements.

If all these problems are solved satisfactorily and Canada does become self-sufficient in oil, whether by use of its own oil—and the possibility of discoveries near the large consuming areas cannot be discounted, or whether by exchange with the Americans, the question which logically follows is "What are the economic consequences to us as Canadians?" The answer to this must be largely speculative, but the record thus far may afford some guide.

In the national sphere Canada saved in 1949 alone an estimated 90 million of vital U. S. dollars. Despite this, the U. S. dollar requirements for oil were roughly 275 million. The total net deficit with the U. S. dollar area in 1949 was less than 400 millions. Self-sufficiency in oil could almost eliminate the troublesome U. S. dollar problem, which would mean a great deal to Canada's national economy. When the Interprovincial pipe line is completed the estimated dollar saving will be 140 millions, with only on third of Canada's petroleum requirements being met. This will rank in importance with Canada's gold mining industry in the solution of the U. S. dollar problem.

1950 Expenditures

In the field of capital expenditure, 1950 will see the spending of $90 million for the Interprovincial Line, $8 million for two new tankers, $30 million for additional prairie refining capacity, and $150 million for exploration and development. The total expenditures by oil companies may be directly responsible for about 10 percent of the total private domestic investment, a remarkable achievement for an industry so new in the Canadian picture. The indirect contribution through induced expansion in other industries is difficult to measure, but is certain to be large.

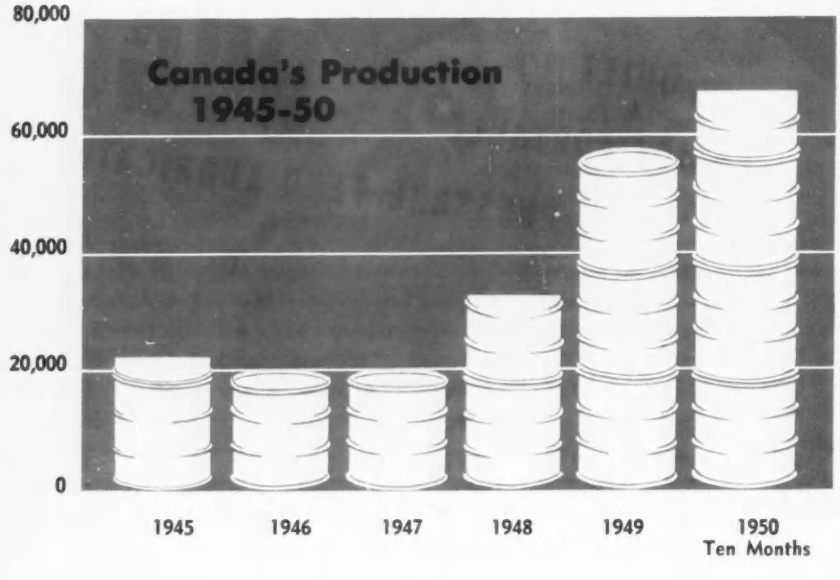
In the more restricted sphere, everyone will agree that oil exploration has done Alberta no harm. It meant in 1949 alone more roads, schools, social services and the like with no added pain to the taxpayer. It also meant the retirement of a substantial part of the provincial debt, and may eventually leave Alberta entirely free of debt. Sales of right to lease Crown reserves alone has brought $32½ million to the treasury so far this year, not to mention reservation fees and extension fees, lease rentals, and royalties.

The oil industry has meant directly an estimated 6000 new jobs and consequently more business for the butcher, the baker, and almost everyone else active in the nation's economy. Scores of new businesses are being established, and new towns are being created. The population of Edmonton has increased from 119,000 in 1947 to close to 150,000 at present. Calgary and many other Alberta centers have experienced similar increases.

Perhaps the most significant change on the prairies, however, is the increase in consumption of petroleum products. The discovery of oil has enabled the prairie consumers to gain some reductions and to avoid several increases in price; Alberta consumption increased 17 percent in 1949 over 1948—the largest increase any place in the world—and no doubt partly due to this fact. Further price decreases should permit the Canadian farmer to adopt more mechanization, enabling him to compete more successfully in world markets, to overcome his present transportation disadvantages. It is said that a nation's productivity can be gauged by its consumption of petroleum. If this be so, the transfer of the prairies from a high cost oil area to a low cost area should mean a great deal to their economy.

So far no mention has been made of natural gas, and perhaps none should be. However, there has been found in Alberta a great deal of natural gas, and if it is decided to permit export, and the gas fields develop, it should mean considerable industrial expansion, not only at the terminii of the pipe lines, but also at and near the fields. There is already one large industrial plant in Alberta, located there because of natural gas. Many chemical industries locate close to the source of cheap natural gas, using certain components of the gas, the removal of which does not interfere with the fuel qualities of the residue. In spite of Alberta's position at the top of the freight rate structure, gas should attract some industries of this nature.

One other advantage which will accrue to the nation from oil development in the Western Plains is the matter of national security. No one doubts that if trouble comes, the direct route between the only two possible contestants lies across the Canadian prairies. The integration of Ca-



Crude Production in Western Canada
(Barrels Daily)

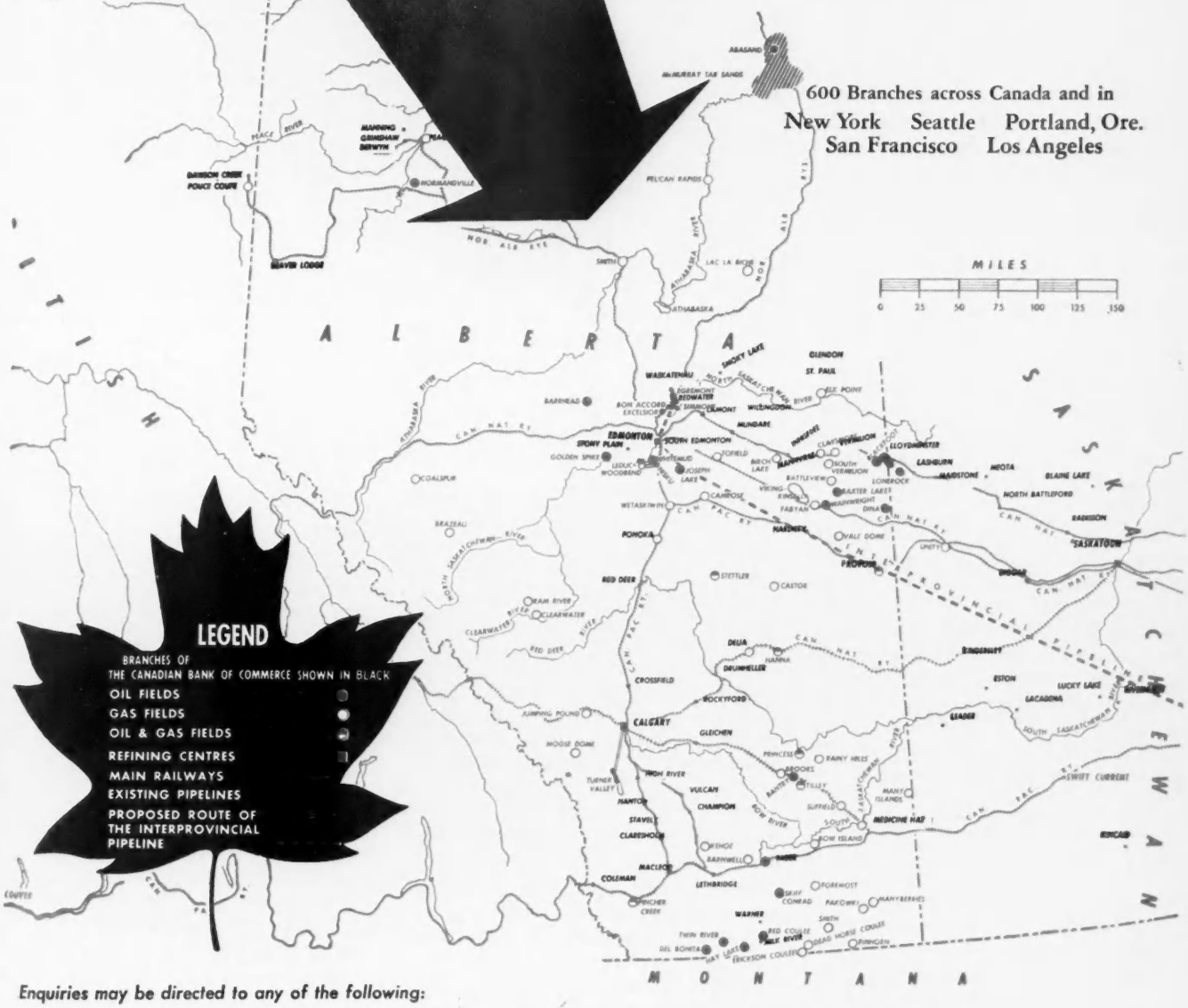
Field and Province	1945	1946	1947	1948	1949	1950 (10 Months)
Leduc-Woodbend	.....	.....	1,021	12,725	26,545	29,204
Redwater	.....	.....	.....	101	13,133	25,699
Turner Valley	20,335	17,457	14,930	13,390	11,792	9,301
Other Fields	1,735	2,101	2,705	3,561	4,000	6,368
Total Alberta	22,069	19,558	18,656	29,777	55,470	70,572
Saskatchewan	45	375	1,480	2,320	2,143	2,773
Total Western Canada	22,114	19,933	20,136	32,097	57,613	73,345

For Oil and Allied Industries . . .*

Oil and gas companies and allied enterprises are cordially invited to enquire about the advantages of a banking connection with The Canadian Bank of Commerce.

Nearly 100 of its 600 branches are located in the oil and gas fields of Western Canada. With knowledge of the oil man's banking needs, we are able to provide *those extra services* which often smooth the way and expedite business.

600 Branches across Canada and in
New York Seattle Portland, Ore.
San Francisco Los Angeles



Enquiries may be directed to any of the following:

Mr. R. H. McDade, *Assistant General Manager*
The Canadian Bank of Commerce
Head Office, Toronto, Canada

Mr. J. P. R. Wadsworth, *Superintendent*
The Canadian Bank of Commerce
Calgary, Alta.

Mr. F. A. Matheson, *Manager*
The Canadian Bank of Commerce
Edmonton, Alta.

* Your copy of the revised edition of our 60-page brochure, "For Oil and Allied Industries," with separate insert of map showing the Oil and Gas fields of Western Canada, may be obtained on request.

The Canadian Bank of Commerce

Head Office: Toronto, Canada

nadian and American defenses makes the strategic location of our oil reserves invaluable in the event of war.

It has been said that the oil industry spent in Western Canada in 1949 more than $100 million. It recovered, over and above royalties, petroleum of a value of about $50 million. This year, it will spend $150 million, and will receive less than $75 million. This disparity between expenditures and receipts is bound to continue for several years if exploration is to continue at anything like its present rate. It is abundantly apparent, therefore, that for some time to come, vast sums of risk capital must be attracted from sources outside the Canadian oil industry.

To better understand the costs and risks involved in seeking oil it is timely to review the steps necessary for an oil company to enter Canadian operations.

In 1887 the Dominion stopped the practice of granting mineral rights along with the surface on homestead entry, and a very minute part of Alberta was homesteaded before that time. The Hudson Bay Company owned its minerals and the railroad land companies were granted the minerals underlying their lands—and until 1910 some of the railroads sold the mineral rights along with the surface. But for this fact, the few farmers at Leduc who profited directly by the discovery of the field would have received nothing.

Only about 7 percent of the minerals underlying the Province of Alberta have been relinquished by the Dominion, and only a small portion of that 7 percent is in the hands of individuals. In Redwater, for example there is not a single quarter section where the farmer who owns the surface also owns the minerals. This should indicate that not many oil-rich farmers evolved from the present oil boom.

The search for oil is a very expensive proposition and it might be well to dispel some of the false ideas about this angle of the business. The procedure followed by a company wishing to explore for oil in Alberta is to apply for a Crown reservation or reservations, unless, of course, it is fortunate enough to secure some choice freehold (privately owned mineral rights) acreage or wishes to buy at great cost the right to lease a piece of proven ground from the Crown. The reservations are usually of 100,000 acres each and may be obtained for a nominal fee and a substantial deposit to guarantee development.

The grantee then proceeds to conduct his surface exploration work, having one or more parties testing the ground for a period of some months. These surface geology and geophysical crews each comprise a great deal of expensive equipment and about 25 highly paid personnel. It is conservatively figured that each such party costs about $25,000 per month to keep in the field. If after thorough investigation a well seems warranted the company may drill one or more wells. These may disprove the lease or they may be "teasers"—not commercial producers, but of sufficient interest to warrant more drilling.

The reservation is good for three years provided extension fees of 30 cents per acre for the second year and 70 cents per acre for the third year are paid, and also provided drilling commences before the end of the second year. By the end of the third year the grantee may have spent anywhere from $300,000 to well over $1 million in testing the reservation. Operation Muskeg, a completely unproductive search in a reservation about 80 miles north of the Canadian National Railroad's main line, along the eastern slope of the Rocky Mountains, cost $1,628,000.

In any event, if production is not earlier secured the grantee must decide by the end of the third year to abandon the reservation or convert to lease. If he decides to lease, he may take up to 50 percent of the reservation in a checkerboard pattern, with each lease limited to 3 x 3 or 2 x 4 miles, to prevent him selecting all the choice property. He must pay rentals thereon at $1 per year per acre with further drilling commitments, and if he finds oil the Crown gets one eighth of gross production as a royalty.

The unleased portion of the checkerboard reverts to the Crown. The right to lease these areas, subject to the one eighth royalty, may be offered for sale by tender, and in the case of proven acreage often brings fabulous sums to the provincial treasury. If production is found by the grantee all the above expense is worth the speculation, but if all his wells turn out to be "teasers" the only winner is the government.

Many companies now operating in Canada have each spent several million dollars without finding a barrel of oil, so it is readily seen that the oil business is highly speculative. Undoubtedly, all the companies operating in Western Canada, successful and not, have spent nearly twice as much as they have received in return.

At the present time only one well in 20 to 25 drilled is productive in Canada, while in the U. S. the ratio is one in five, yet the industry will spend in excess of $150 million for exploration this year. Well over 100 million acres are under reservation or lease and are, or will be undergoing examination. This area stretches all the way from the Northwest Territories to the U. S. border, and from the Rocky Mountains into southwestern Manitoba. Reserves of over 1 billion barrels have so far been found in little less than four years.

For Canada to prosper from its new-found stores, it is essential that the government take a realistic view of the risks inherent with the oil business. If Leduc and Redwater are not simply freaks of nature; if the governments, both Dominion and Provincial, create with their legislative policies a healthy atmosphere which will not only permit but encourage the application of risk capital in the development of our resources; and if industry thinks soundly and plans thoroughly, it seems entirely likely that the discovery of oil in Western Canada may be as significant in the development of this nation in the last half of this century as was mining in the first half. At least, that is the hope and the expectation of the oil industry.

About the Author

G. W. AUXIER was graduated from the Law School of the University of Alberta with B.A. and L.L.D. degrees and has had his own law firm in Edmonton for the past 20 years. The honorary degree of K.C., King's Counsel, was given him by the Province of Alberta for his outstanding work in the fields of taxation and administrative law, two subjects which he has taught at the University of Alberta. He is also a "bencher" of the Alberta Law Society, a 13-man board set up to guide the activities and ethics of the law fraternity. Because of his knowledge of provincial law and leasing requirements, Auxier was appointed to his present position with the Western Canada Petroleum Association in February.

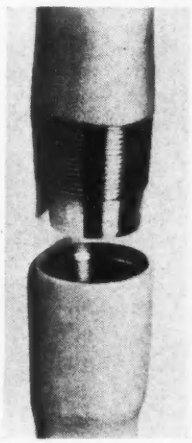
NEW AND IMPROVED EQUIPMENT

SUPPLEMENTING COMPOSITE CATALOG

Integral Joint Tubing

This item supplements The National Supply Company data on pages 3433-3564 of Composite Catalog, 17th Edition.

Leakage of oil well tubing joints in high pressure condensate and flowing wells can be obviated with a new oil well tubing connection, according to the manufacturer. The new product, known as Spangseal, consists of an integral joint equipped with the standard API thread in conjunction with a conical sealing surface, thus eliminating couplings.



Thread dimensions are the same as the corresponding sizes of API External Upset Tubing. The conical sealing surface is at the small end of the threaded section on both male and female ends. When the joint is made up, the two sealing surfaces effect a seal ahead of the threads.

Internal pressure tests showed no joint leakage when pressure was built up to 7000 psi, followed by submersion in boiling water until an internal pressure of 12,000 psi was reached. This was followed by rapid cooling in ice water. After 174 complete cycles there was no evidence of joint leakage, the manufacturer claims.

For additional information write the Spang-Chalfant Division, The National Supply Company, Grant Building, Pittsburgh.

Pumping Unit

This item supplements International Derrick & Equipment Company data on pages 2477-2536 of Composite Catalog, 17th Edition.

A polished rod load capacity of 15,000 pounds and a peak torque capacity of 114,000 inch pounds are claimed for a new pumping unit, the F16-DA114.

The new pumping unit has the Ideco wheel type counterbalance crank, a rigid four-legged samson post, a sturdy, welded sub-base under the reducer and clamp type pitman connections.

The speed reducer is fitted with herringbone gears and all shafts are carried on roller bearings. A magnetic type oil sump and labyrinth seals on all shaft extensions assure a continuous supply of clean lubricant.

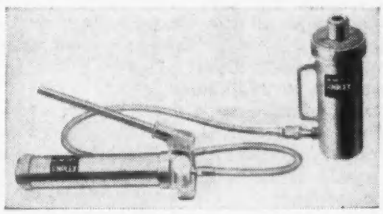
For additional information write International Derrick & Equipment Company, P. O. Box 1331, Dallas 1.

Remote Control Units

This item supplements Templeton, Kenly and Company data on pages 4660-4661 of Composite Catalog, 17th Edition.

A complete new line of remote control hydraulic ramps and pumps is available for use where limited space or other difficulties make the use of self-contained jacks impossible. They are light-weight and easily portable.

The "Re-Mo-Trol" unit enables the operator to lift, pull or push from a distance



and in any direction—up, down, sideways or at an angle. A "center hole" tubular ram used on units of 30-ton and greater capacity enables the use of these units as pullers. A rod or bolt inserted through the ram and secured over the ram head can be pulled through the ram as it extends.

Seven models are available, ranging from 10 to 100-ton capacities. The pumps operate at a maximum of 10,000 psi, with overload safety protection.

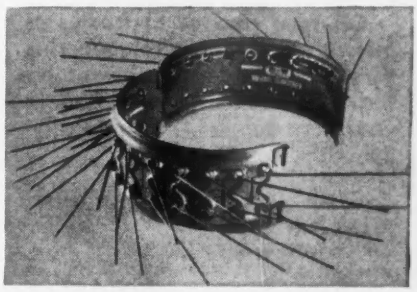
For additional information, write Templeton, Kenly and Company, 1022 South Central Avenue, Chicago.

Save Time—Write Direct

As a service to readers, all items in WORLD OIL include the complete mail address of the manufacturer. This makes it possible for those desiring additional information to write any manufacturer without the delay occasioned by going through offices of WORLD OIL, and enables subscribers to request specific data in which they are particularly interested.

Scratcher

This item supplements B & W Inc. data on pages 481-486 of Composite Catalog, 17th Edition.



A new scratcher has double hinge construction for simplified installation on the casing string. The lugs or stops which determine proper scratcher spacing are welded on the casing joint at the pipe yard, marine dock or casing rack. B & W Nu-Coil hinged scratchers are latched on between the stops just before the casing is run in the hole by inserting a strong pin in the latch opposite the hinge.

Double-hinge construction enables the scratchers to be used on external upset casing and simplifies racking procedure for marine operation or wherever rack space is limited, the manufacturer claims.

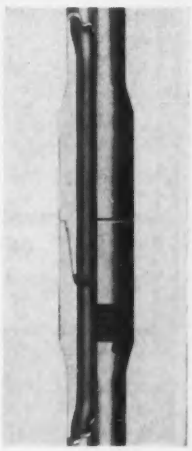
The spring wire scratching fingers are five inches long, project outward from the sleeve at an angle, and reverse their position for effective scratching when the casing is raised and lowered during cementing operations.

For additional information write B & W Inc., P. O. Box 5256, Houston 12, or 3545 Cedar Avenue, Long Beach 7, Calif.

Tool Joints

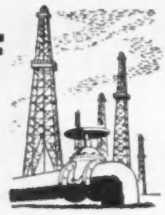
This item supplements American Iron & Machine Works Company data on pages 229-280 of Composite Catalog, 17th Edition.

"Flash Welded" tool joints are available for all popular sizes of API drill pipe, with or without hard metal bands, and in a choice of 18-degree or square shoulder design.



The manufacturer has installed modern flash weld equipment and testing facilities at its Oklahoma City plant, and is producing the joints which offer the advantages of a unitized drill stem.

For additional information write American Iron & Machine Works Company, P. O. Box 1177, Oklahoma City.



TALK OF BEING VITAL...

Trans-Texas brings *exclusive* air service to no less than twenty Texas cities and towns. That means *twenty* communities entirely dependent on Trans-Texas Airways for direct air mail, air freight and air passenger service.

Oil men and other businessmen have come to rely on this service . . have come to realize that Trans-Texas *gets you where you want to go* — economically, speedily, comfortably.

For information call Trans-Texas Airways or your travel agent.

TRANS-TEXAS *Airways*

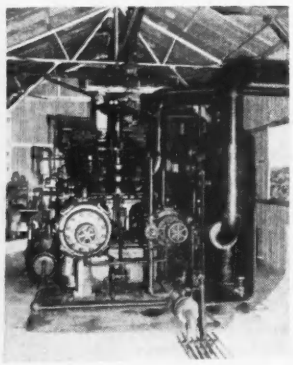
SECONDARY MODERN RECOVERY

TECHNICAL CONSULTING
PRODUCTION ENGINEERING
SERVICE, INCLUDING
CORE ANALYSIS

PRESSURE MAINTENANCE WITH GAS OR WATER

REPRESSURING WITH GAS OR WATER

Package Unit Pressure Maintenance Installation



CARTER COUNTY, OKLAHOMA

SURVEYS
ESTIMATES
DESIGN
INSTALLATION
SUPERVISION

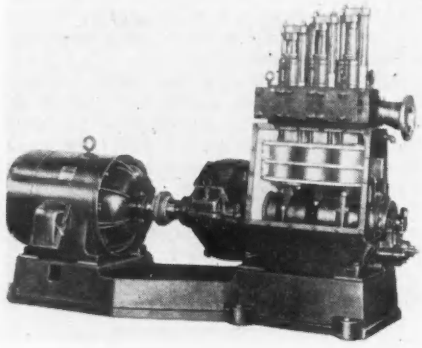
PETROLEUM ENGINEERS
CABLE & STINE
WICHITA FALLS, TEXAS

NEW EQUIPMENT

SUPPLEMENTING COMPOSITE CATALOG

Direct Flow Pump

This item supplements The Aldrich Pump Company data on pages 174-175 of Composite Catalog, 17th Edition.



A new direct flow pump offers greater volumetric efficiency, due to reduced space between valves, and lower operating and maintenance costs, the manufacturer claims.

Designed to permit direct or through-flow of liquids, the pump employs a sectionalized fluid end composed of separate units which include the working barrel, stuffing boxes, valve units, plunger, and suction and discharge manifolds. Individual fluid end sections can be replaced, and since almost all the wearing parts are interchangeable, only three sets are necessary to cover a total range of pump sizes from 100 to 2450 horsepower.

Direct flow pumps are adaptable to oil industry applications such as primary and secondary recovery, recycling, salt water disposal, crude oil gathering lines and product lines.

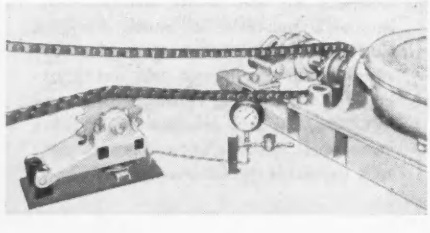
For additional information write The Aldrich Pump Company, 12 South 12th Street, Philadelphia 7, Penn.

Torque Indicator

This item supplements Hunt Tool Company data on pages 2353-2384 of Composite Catalog, 17th Edition.

A new, simple torque indicator for power rigs consists of a hinged sprocket assembly, diaphragm, hydraulic gauge and hand pump.

The indicator sprocket is positioned so the rotary chain rides on it, and any change in torque is reflected by more or less pressure on the sprocket assembly against the diaphragm which passes the change along to the gauge. The indicator assembly may be used on any type power rig and chain guards, with or without oil bath.



For additional information write Hunt Tool Company, 1945 Cullen Boulevard, Houston.

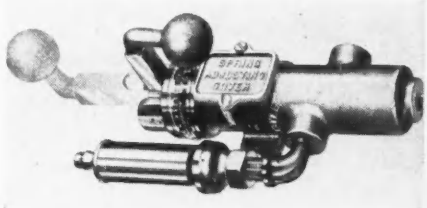
Low Pressure Alarm

This item supplements Mid-Continent Supply Company data on pages 3277-3304 of Composite Catalog, 17th Edition.

Positive warning when lube oil pressure fails is sounded by a new low pressure alarm.

Operation of the alarm is automatic and installation is simple. It is attached to the engine block or any other convenient location and put into operation by attaching the air line and lube oil pressure line to the points marked on the unit.

If lube oil pressure fails, the piston in the cylinder is retarded enough to permit the

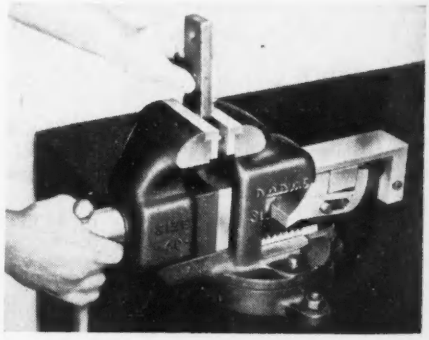


air to pass through and operate the whistle which will sound until the lever is flipped into the vertical position.

For additional information write Mid-Continent Supply Company, Mid-Continent Building, Fort Worth, Texas.

Machinist's Vise

This item supplements Dodge Manufacturing Corporation data on pages 1376-1379 of Composite Catalog, 17th Edition.



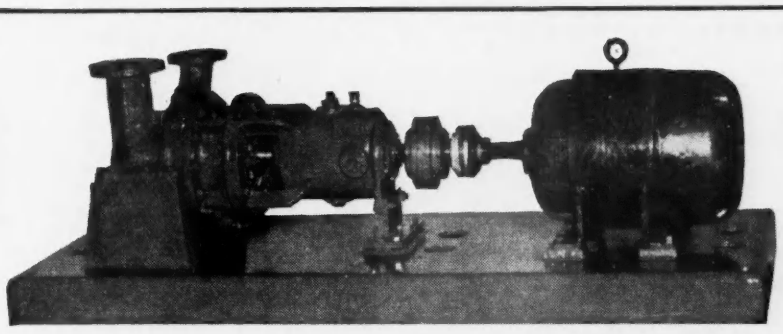
A new quick-action machinist's vise opens or closes to any position in one second through a push-pull action which eliminates spinning the handle.

With the handle in "neutral" position, the jaw slides to any position. When the work is engaged the vise operates in the conventional manner.

The vise is provided with either swivel or stationary base and is built in four-inch size.

For additional information, write Dodge Manufacturing Corporation, 1938 William Street, Mishawaka, Ind.

ALLIS-CHALMERS
PUMPS for the Oil Industry
OIL WELL...TANK CAR...REFINERY



Type SS-OP special process pump with water cooled bearings and stuffing boxes for applications in oil refineries and chemical plants. (Size 3 x 2 illustrated).

MADE IN CANADA

A-C ALLIS-CHALMERS

Canadian-Allis Chalmers builds for Canada's oil and gasoline industry pumps specifically designed to handle hot oil and other liquid hydrocarbons. The pumps may be readily serviced by removing the complete rotating element without disturbing the suction piping, the discharge piping or the prime mover. Many types of materials are utilized to combat the various corrosive conditions encountered. Mechanical rotary seals are optional on all sizes.

CANADIAN ALLIS-CHALMERS LIMITED

GENERAL OFFICES and WORKS: LACHINE, QUE.

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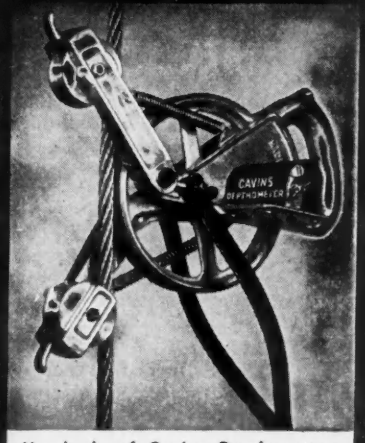
50-CAL-11

Here's the Accurate Way to take Wire Line Measurements

Easy to use

Light and handy to carry

No more "Stringing-in" Guess Work



Gives you accurate depth

Direct reading

Pays for itself in a short time

Hundreds of Cavins Depthometers are in successful service giving their owners direct-reading, accurate well measurements. This strong, simple device comes in a handy carrying case (weighs only 17 pounds)—is put on the line in a few seconds, and tells you where bottom is quickly and dependably. —Write for folder to The Cavins Co., 2853 Cherry Ave., Long Beach 6, California.

THE CAVINS DEPTHOMETER

BEAVER 26-R

the only tool of its kind that . .

. . . cuts either standard "taper" or electric "straight" conduit threads by a simple adjustment.

. . . has "radio" dial size-setting. Dies can be removed in a few seconds FROM THE OUTSIDE without use of tools.

. . . is fully-adjustable and easy-working. The only 1 to 2-inch pipe threader that cuts standard, oversize and undersize threads of uniform standard length.

The Beaver 26-R uses one set of dies to thread four sizes—1, 1¼, 1½ and 2-inch. It is fully-adjustable for oversize or undersize threads to compensate for variation in fittings. There's a cam-type universal self-centering chuck, too, which centers the pipe accurately and insures straight pipe lines. Yet, "drip threads" may be cut when desired for heating lines.

Available at all leading supply houses—don't accept substitutes. Competitive in price!

SEND FOR BEAVER CATALOG NO. 50. Address Beaver Pipe Tools, Inc., 254-300 Dana Avenue, Warren, Ohio, U. S. A.

BEAVER PIPE TOOLS

254-300 DANA AVENUE WARREN, OHIO, U. S. A.

NEW EQUIPMENT

SUPPLEMENTING COMPOSITE CATALOG

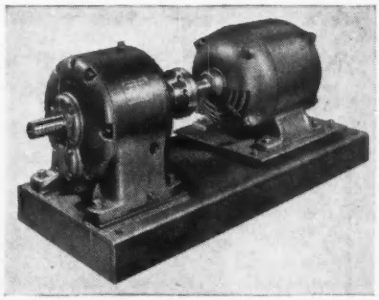
Packaged Power Unit

This item supplements Link-Belt Company data on pages 2873-2908 of Composite Catalog, 17th Edition.

The Motogear, a new packaged power unit, consists of an enclosed helical gear drive with separate standard motor, flexible coupled and mounted on one welded steel base plate.

A movable plate between motor feet and welded base plate provides for adjustment, should shaft realignment be necessary.

Motogears are built in a variety of sizes, in double or triple reductions, and in a wide range of ratios and horsepowers. Input and output shafts are concentrically in line. The helical gear drive is like that used in the corresponding Link-Belt Gearmotor, but on the Motogear the motor is coupled to input shaft and mounted on a base plate instead of being integrally



secured to side of drive. The helical gear drive is also available as a separate self-contained unit without the motor.

For additional information write for Book 2247, Link-Belt Company, 307 North Michigan Avenue, Chicago 1.

For HEAVIEST DUTY

PARAFFIN SCRAPING

- NEW DESIGN
- GRIP OF STEEL
- LONGER WEARING

More strength, wearability, and holding power here! The new M-25 S-I-W Paraffin Scraper hugs the rod with as much as 5000 pounds of GRIP! It stays put!

Field installation, with special S-I-W tools, is easy. The new M-25 has a super rugged design. Two heavy steel blades curl around the two shell halves to which they are welded. They exert continuous unplugging effect with every pumping stroke.

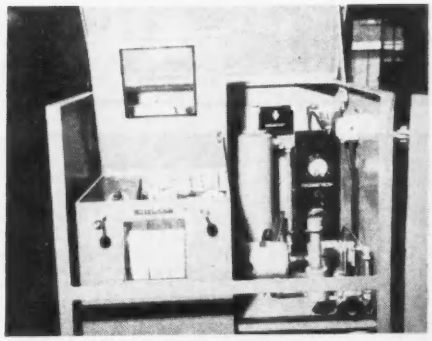
Check these big M-25 features: easy field installation . . . maximum effectiveness . . . reasonable cost. The new S-I-W M-25 scraper is a bear for wear . . . a profit-saving paraffin control tool!

Sunshine Iron Works

601 W. MURPHY - PHONE 4374 - ODESSA, TEXAS

Formation Logger

This item supplements Petroleum Instrument Company data on pages 4100-4101 of Composite Catalog, 17th Edition.



A new Formation Logger embodies the principles of two instruments: the drilling rate recorder and the formation gas detector. This unit permits the drilling operator or geologist to obtain a constant recording of the rate-of-bit-penetration, thus identifying drilling breaks. The gas detector records the presence, or absence of hydrocarbons in these formations. The instrument may also be used as a warning device in detecting the existence of dangerous gas-cut mud.

The drilling rate portion of the unit embodies an electrical circuit that records the interval required to drill two feet. The gas intensity system involves the Wheatstone bridge and detector filament; this information is recorded by means of a galvanometer and attached inking pen. In use, the instrument is placed away from disturbing rig vibrations and connected to the gas trap on the flow line by means of rubber hose. Drive lines strung in the derrick transmit the motion of the drill string to the recording unit. The entire instrument is contained in a weather-proof cabinet; only maintenance operations required are winding the clock and changing the 24-hour strip chart.

For additional information write Petroleum Instrument Company, 220 West Alabama, Houston.

LE GRAND

Pumping Units

Unit Illustrated is the 25/72.C.C. Model with double helical double reduction gear box.

330,000 lbs. ins. Peak Torque.

Polished Rod Load 25,000 lbs.

Polished Rod Strokes. 24″ 36″ 48″ 60″ 72″.

LE GRAND SUTCLIFF & GELL LTD

SOUTHALL, MIDDLESEX & ROCHESTER, KENT, ENGLAND

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OILFIELD EQUIPMENT MANUFACTURERS & FOUNDERS

NEW EQUIPMENT

SUPPLEMENTING COMPOSITE CATALOG

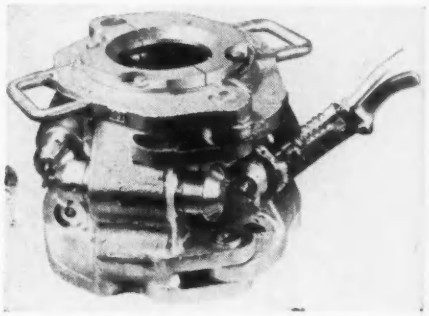
Tubing Spider

This item supplements Kinzbach Tool Company data on pages 2653-2672 of Composite Catalog, 17th Edition.

Parallel-operating linkage for gripping and suspending the tubing is used instead of conventional conical wedges in a new automatic tubing spider.

A single lever control actuates all segments simultaneously and in proper relation. The control lever is attached to one of the bevel-gear quadrants connecting the ends of the cam shafts. An indexing pin, operated by a squeeze grip on the control lever, permits locking the segments positively in engaged on disengaged position.

Parallel cams used as load connectors between the segments and the spider body make it possible to hold all segments in



alignment with the tubing at all times and to maintain a gripping force which is proportional to the load.

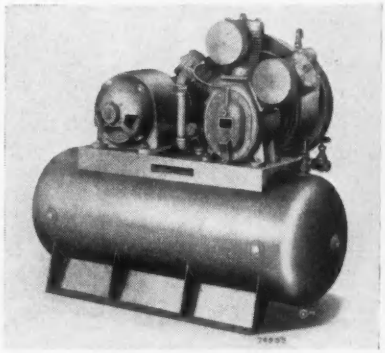
While segment movement centralizes the tubing within the spider body, sufficient lateral clearance is provided at their connection with the cams to permit their adjustment to the tubing contour while closing. This clearance causes the segments to wedge against rotation of the tubing as the tonging force is applied. The assembly is hinged for positioning around the tubing by the removal of one locking pin.

The spider is available for tubing sizes from 2 through 3 inches.

For additional information, write Kinzbach Tool Company, 2411 Summer Street, Houston.

Compressors

This item supplements Ingersoll-Rand Company data on pages 2465-2472 of Composite Catalog, 17th Edition.



A new series of air compressors consists of two lines, one designed for normal industrial pressures of 100-125 pounds; the other rated at 200 pounds for continuous service, and up to 250 pounds on intermittent pump-up service. Both lines are available as tank-mounted, baseplate-mounted or bare units, with electric-motor or gasoline-engine drive. The units are air cooled by means of fan blades integrally cast on the flywheel.

Standard equipment includes a centrifugal unloader, intake filter and muffler, and automatic start-and-stop control on tank-mounted and baseplate-mounted units. Constant-speed and dual-control are optional equipment.

For additional information write Ingersoll-Rand Company, 11 Broadway, New York 4.

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FOR FAST . . . EFFICIENT . . .
WELL SUPERVISED DRILLING OPERATIONS
In Wildcat or Proven Areas

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NEW EQUIPMENT

SUPPLEMENTING COMPOSITE CATALOG

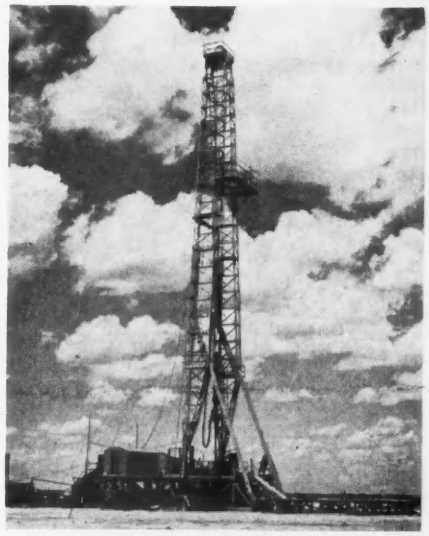
Portable Drilling Mast

This item supplements International Derrick & Equipment Company data on pages 2477-2536 of Composite Catalog, 17th Edition.

Improved visibility, greater floor space and high safety are claimed for a new portable drilling mast, the Ideco "Full-View." The A-frame structure is held in the upright position by a pair of auxiliary legs which serve also as a part of the raising mechanism — no guys are required. Braces and girts thus do not obstruct the driller's view of the traveling block or derrick man.

Wide-spread legs permit use of any type or size drilling rig and provide clear space around the catheads. The drilling floor measures 24 feet from drawworks to pipe ramp and 27 feet 8 inches from side to side.

Raised by means of the traveling block, the mast is pushed toward drilling position by a pair of raising legs, pivoted at ground level. As the traveling block moves toward the crown, it pulls on raising lines which are reeved as a block-and-tackle inside the bottom mast sections. The other ends of the raising lines are attached to the top of the raising legs which are fitted with rollers that follow a track built inside the mast. As the rollers move downward along the track, they tilt the mast upward. Automatic safety locks are engaged by the roller shafts as the mast approaches vertical, holding it in an upright position. Lock jacks further secure the upright position.



For additional information write Department 215, International Derrick & Equipment Company, P. O. Box 1331, Dallas 1.

L-O-N-G-E-R
THREAD LIFE

1. EXCLUSIVE 500-TON SPECIAL prevents washouts and galling. Makes breaking out easier; withstands highest pressures, and is unaffected by heat and moisture!
2. KANT-GALL TOOL JOINT COMPOUND
3. LONG-LIFE DRILL COLLAR COMPOUND

SOLD BY SUPPLY STORES EVERYWHERE

PETROLEUM DISTRIBUTING CO.
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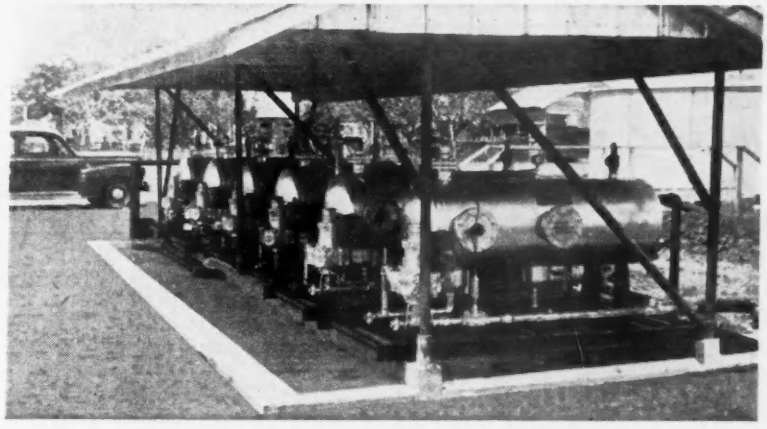
PERMANENT AND PORTABLE
OIL AND GAS SEPARATORS



This battery of six skid-mounted 4-1H-2406 Rolo Wellcheckers makes it possible to produce six one-well leases into a single tank battery. Installations of this type, of which Rolo Mfg. Co. has made many, are approved by regulatory bodies. Let us work with you on your problem.

Rolo Wellcheckers are made in all sizes to fit any operation. See Composite Catalog or write for illustrated Bulletin.

Oil Well Metering Specialists

ROLO MANUFACTURING COMPANY

2510 South Blvd., Houston 6, Texas
BRANCHES: Corpus Christi, Midland, Kilgore, Tulsa, New Orleans, Los Angeles, Casper, Calgary, Alta.
EXPORT OFFICE: R. S. Stokvis & Sons, Inc., 17 Battery Place, New York, N. Y.

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NO-SMOKE

STANDCO BRAKE LINING

Nothing novel—no bunk, but it gets the job done without scoring brake rims. See pages 3973-3978 Composite Catalog.

Standco Brake Lining Co.
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Hydrocarbon Gas Analyses, Reservoir Equilibria Studies for Crude and Condensate well, Waters, Brines, Corrosion and Industrial Analyses.
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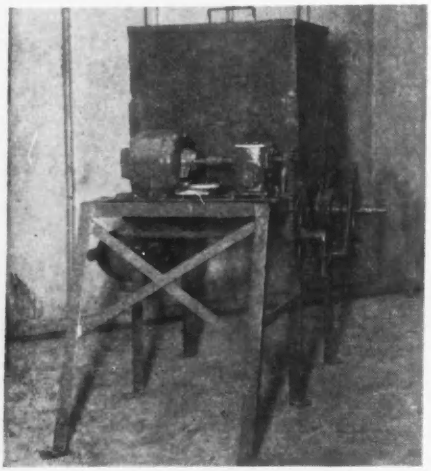
Be Sure to Check
The Trading Post
PAGE 326

OTHER NEW AND IMPROVED EQUIPMENT

Chemical Feeder



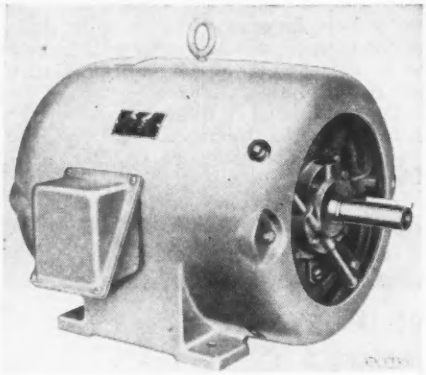
The Western Chemical Feeder is an automatic water treater adaptable in waterflood operations and which is driven by the water entering the treating plant. When once adjusted for the correct amount of chemical to the correct amount of water, the amount of chemical fed will be increased or decreased in proportion to the amount of water passing through the feeder. If the water supply is interrupted, the feeder automatically stops, to start again when the flow of water is resumed. Chemical feed is adjustable two ways: (1) by regulating the flow of water over the driving wheel; (2) by adjusting the eccentric on the idling shaft to engage more or less teeth on the auger drive shaft.

For additional information, write Keystone Supply Company, 312 East Cherokee Street, Nowata, Okla.

Cast Iron Frame Motors

Cast iron frame totally enclosed fan-cooled motors are available in ratings from 5 horsepower through 250 horsepower in both standard (type EP) and explosion-proof (type JP)designs.

Frame, endplates, blower shield and conduit box are all of rugged cast iron. The one-piece blower shield has integrally formed air intake to protect the external blower. A shield on the drive end deflects the emerging air stream around the bearing. Blowers on EP motors are of malleable iron, and those on JP's are non-sparking bronze. On all but the larger designs, the blower design permits operation of the motors in either direction or rotation. The rotor squirrel cage is of cast aluminum.

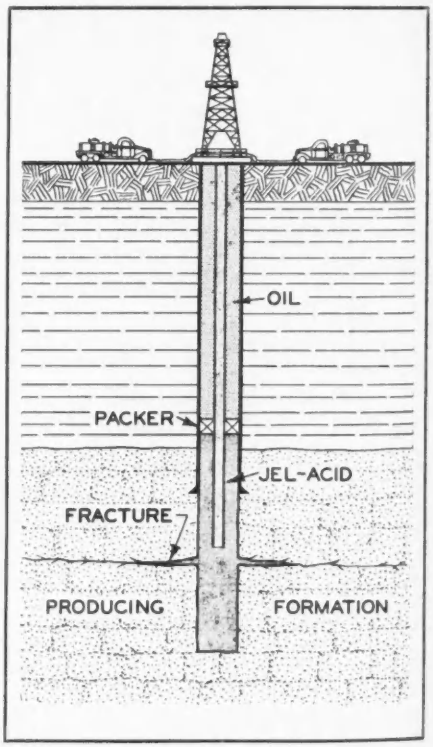


For additional information write Wagner Electric Corporation, 6400 Plymouth Avenue, St. Louis 14.

Fracturing Process

A new process of fracturing formations to increase production, known as Stratalift, utilizes "Jel-Acid" to step up production from those formations which do not respond readily to conventional acid treatment. Dowell Jel-Acid, a thickened hydrochloric acid, is both an efficient formation fracturing agent and a solvent capable of removing acid soluble materials that may be present in the rock. The acid is carried to the job in the form of two non-viscous solutions which are pumped into the well simultaneously. Since the chemicals are previously dissolved, no time is lost in preparation on location. The two solutions are mixed at the discharge of the pumps, forming Jel-Acid in the tubing.

Because the viscous material does not have to pass through the pumps, a wide range of viscosities can be used to meet specific well conditions. The viscosity of Jel-Acid can be controlled to yield liquids ranging from slightly thickened solutions to those as thick as cup grease. This range in viscosity makes Stratalift adaptable to most formations, regardless of permeability.



For additional information write Dowell Incorporated, Kennedy Building, Tulsa 3.

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Arrive KINGSTON	2:02 AM	Arrive NEW ORLEANS	5:00 PM
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C&S New Luxury Constellations offer the fastest service in history from Houston to St. Louis and Chicago.

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GENERAL OFFICES — *15th Year of Perfect Safety* — MEMPHIS 2, TENN.

Threaded Plastic Pipe

Threaded sections and molded fittings, now available in Carlon plastic pipe, facilitate installation of standard or intricate systems for handling fluids or gases. The new pipe, Carlon "TL," is available in 20-foot lengths and has standard International Pipe Threads. The light-weight pipe has diameters ranging from ¼ to 2 inches. It is immune to rot, rust and electrolytic corrosion.

For additional information, write Carlon Products Corporation, 10211 Meech Avenue, Cleveland 5.

Portable Seismograph

A new model 25 trace Unitized Portable Seismograph, with 24 amplifiers, is housed in one water-tight stainless steel case weighing 55 pounds. Amplifiers are high gain AVC or expander type with individual gain controls, filter switches, high line eliminators and a built-in cable tester is provided on each amplifier channel. The unitized construction eliminates jumper cables, and the need of several men for carrying purposes. A wide choice of filters is available to meet the requirements of all areas. A new type circuit provides improved record control.

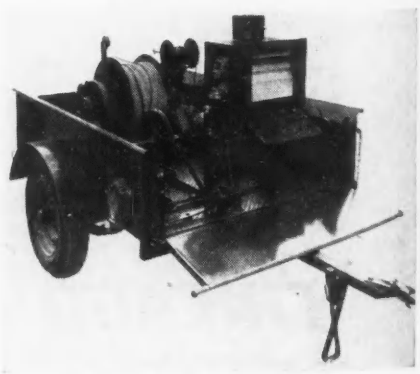
The unit has automatic trip circuit, accurate timing check, and plug-in amplifier. Hinged panel construction allows long access to internal wearing.

For additional information, write Technical Instrument Company, 3732 Westheimer Road, Houston.

Electric Logger

A complete line of electric logging instruments is now available for sale or lease for the first time, the manufacturer states. The instruments are engineered and designed to solve specific problems encountered in various types of exploration.

For additional information write Well Instrument Developing Company, P. O. Box 2406, Houston.



Eagle-Picher Lead Wool

STOPS

bottom water

Rule out the risk of oil-wasting bottom water shutdown by tamping Eagle-Picher Lead Wool in the hole. The finely stranded, flexible metallic wool makes a water-tight plug that seals every crack and crevice. Comes in convenient 50-pound sacks—easy to place in special cartridge-shaped Eagle-Picher Wire Containers sized to fit all casings. Order through your jobber.

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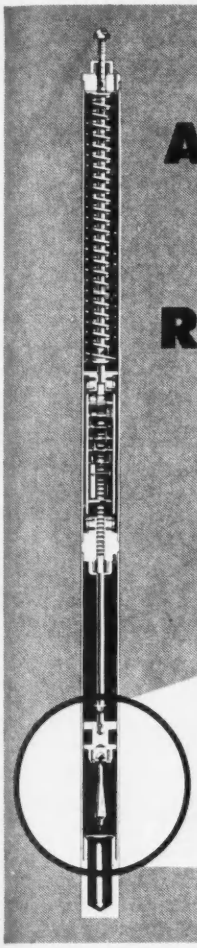
These **3** *Eagle-Picher Bearing Metals meet most requirements*

1. **Dreadnaught** — for extreme speed and heavy-duty conditions.
2. **Outlasta** — for medium speed and average-load conditions.
3. **Durable** — for low speed and light-duty conditions.

ADD "SURE SHOT"

(DEVIATION SURVEYING INSTRUMENT)

TO YOUR RIG EQUIPMENT



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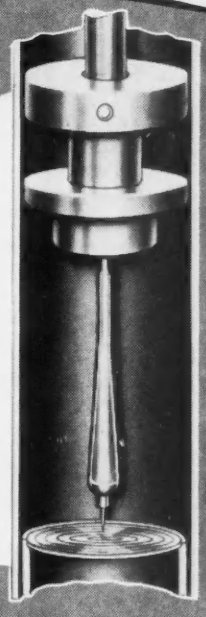
OF WELL BORE DEVIATION

EASILY RECORDED BY DRILLERS



A-1

This advertisement shows one of many tools A-1 Bit & Tool Company is proud to offer the oil industry. It is sold direct, with no servicing required. For additional information write in care of Box 2133, Houston 1, Texas or 30 Rockefeller Plaza, New York 20, N. Y.

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Economics and management practice

especially for engineers in oil and gas production

Here's a reference to help you become as efficient a *businessman* as you are an *engineer*. Designed for engineers engaged in the management of oil- and gas-producing properties, the book covers all important aspects of petroleum engineering economics and business administration. It clearly explains the principles of economics as they apply directly to the petroleum-producing industry. Such topics as oil and gas land acquisition and control—labor management—oil-industry taxation—cost accounting for oil production—and oil and gas conservation *are all clearly and concisely covered.*

The 3rd volume in the
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The Third Volume of the trilogy on petroleum production engineering, *PETROLEUM PRODUCTION ECONOMICS* emphasizes the economic aspects of the industry, providing a *business* supplement to the two previous volumes: *OIL FIELD EXPLOITATION* and *OIL FIELD DEVELOPMENT.*

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SLIP-ON-FITTINGS

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By eliminating threads and grooves Enardo Slip-On Fittings slice 2/3 off line-connecting time. The flexibility of these performance-engineered fittings assures leak-proof connections even on misaligned joints. No expansion joints required. Available in all styles and four sizes, 2 to 6 inches, for working pressures up to 125 lbs. Perfect for lease work because of their full salvage value. For Canadian delivery write National Tank Co., Ltd., Box 4184, Edmonton Station, Alberta, Can.

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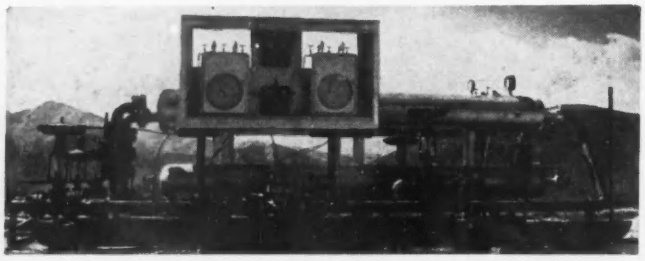
Tulsa, Okla.

Horizontal Separator



A new two-stage, skid mounted horizontal separator is now being used for test purposes on certain wildcat wells in California. The new units, which can be moved from well to well, as needed, can be quickly disconnected because of the use of a minimum of fittings, and towed to the next location. The skid base is of a simple design somewhat like a sled runner. This arrangement allows the separator to be used on a new well until it is determined whether the well is producing satisfactorily. It not, the unit is disconnected and removed to the next location. This model operates with 600 pounds high pressure, 150 pounds low. The skid mounted separators are used individually or in tandem, as desired.

For additional information write American Pipe and Steel Corporation, Alhambra, Calif.

Ground Clamp

A new light-weight ground clamp of 300 ampere capacity, the GC-3, provides a readily movable, yet solid ground connection for welding jobs. The clamp weighs 1½ pounds and has a jaw spread of

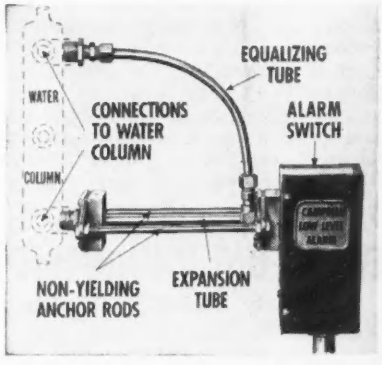
2½ inches. A heavy direct acting spring gives a positive, slip-proof connection with the work. The frame is made of pressed steel, and the jaws are of a steel and copper alloy, "Lincalloy."

For additional information write The Lincoln Electric Company, 13010 Colt Road, Cleveland 1.

Boiler Alarm

A sensitive device for boilers to sound an alarm when the water level reaches low, the Campbell Micro-Thermal low-level boiler alarm, consists of a ⅜-inch expansion tube with its inner end connected to the lower end of the water column on the boiler. Its outer end is connected to the upper part of the water column by means of a 5/16-inch copper tubing.

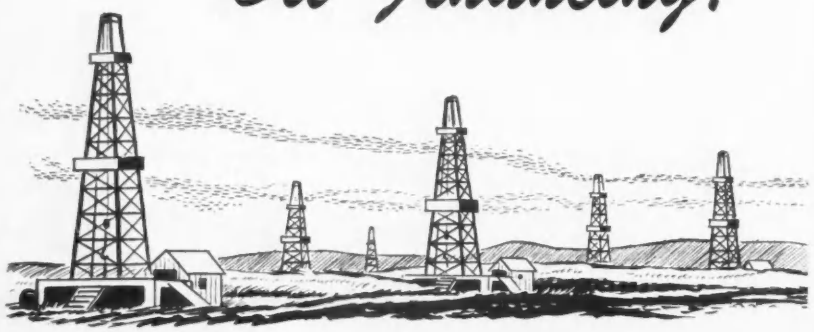
The water rises and lowers above the expansion tube. When the water level reached its low level the increased heat



in the tube expands the tube which actuates a micro-switch. The switch is a double throw type and one throw is connected to a doorbell, buzzer, bell or howler. The other may be connected to a solenoid valve in the fuel line, if desired, for extra safety so that when the water level gets low it will shut off the boiler fuel. A simple screw adjustment at the end of the expansion tube permits setting at any level desired.

For additional information, write J. A. Campbell Company, 645 East Wardlow Road, Long Beach 7, Calif.

Thinking of Oil Financing?



Owners and producers of oil and natural gas are invited to consult with our Oil Department on their financial problems.

All inquiries on petroleum and related matters will receive prompt attention.

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120 BROADWAY

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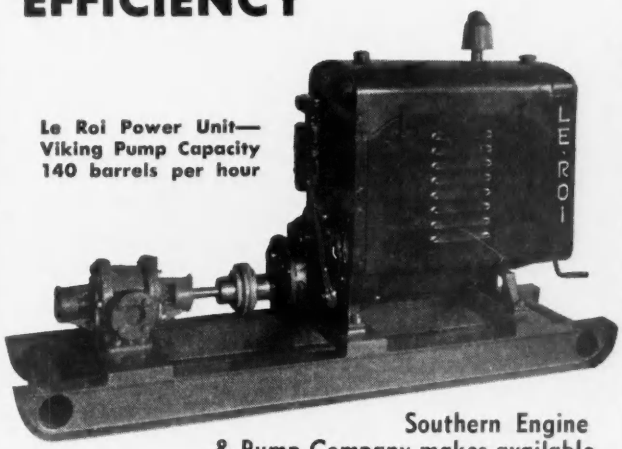

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Viking Pump Capacity
140 barrels per hour

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Capacities up to 5,000 B/D

Pressures up to 10,000 P.S.I.

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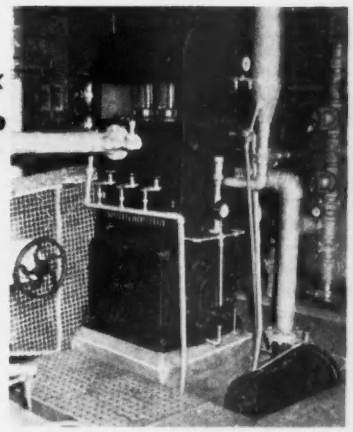

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FEATURES: Pump has no gears
Totally-enclosed Power End
Pressure Oiling System

Plungers on top; patented stuffing boxes; completely accessible; roller bearings; no adjustment necessary; dry joint between liquid end and power end; no leakage into power end. Heat-treated stainless steel valve service; long lift; minimum maintenance; metal-to-metal joints on all valve plugs; no gaskets to blow; constant speed; constant capacity.

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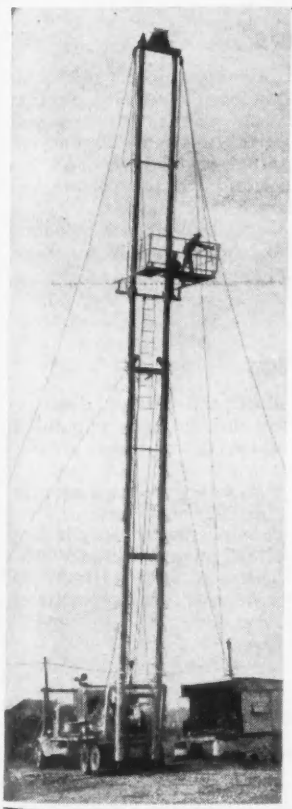

S & R

Custom Built

PORTABLE TELESCOPING POLE MASTS

This S&R double ladder mast is of heavy welded steel construction, and is fabricated of 10¾" pipe and 8⅝" pipe. Overall dimensions when erected 87 feet to crown support beam and 50' 2" when telescoped in travelling position.

Approximate weight of the complete equipment is 12,000 lbs.

The complete assembly includes the (1) poles, (2) breakdown shaft assembly, (3) attached racking platform (which positions itself when poles are raised), (4) pole adjusting screws, (5) a sheave assembly to be mounted on truck or trailer for raising the poles, (6) and a four or five 24 inch sheave crown block for ¾" line.

Available for truck, trailer, or skid mount.

For additional information write, wire, or phone

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FOR CLEAN OIL *and* CLEAN ENGINES

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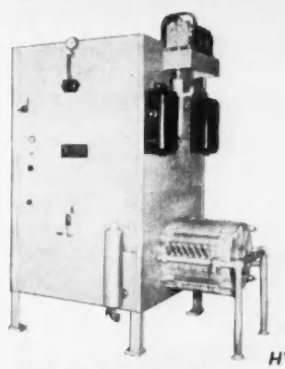
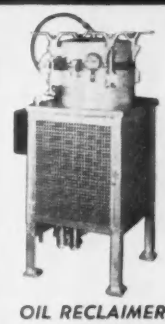


AIRLINE OIL PURIFIER

HYFLOW OIL FILTERS



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Drilling Fluid

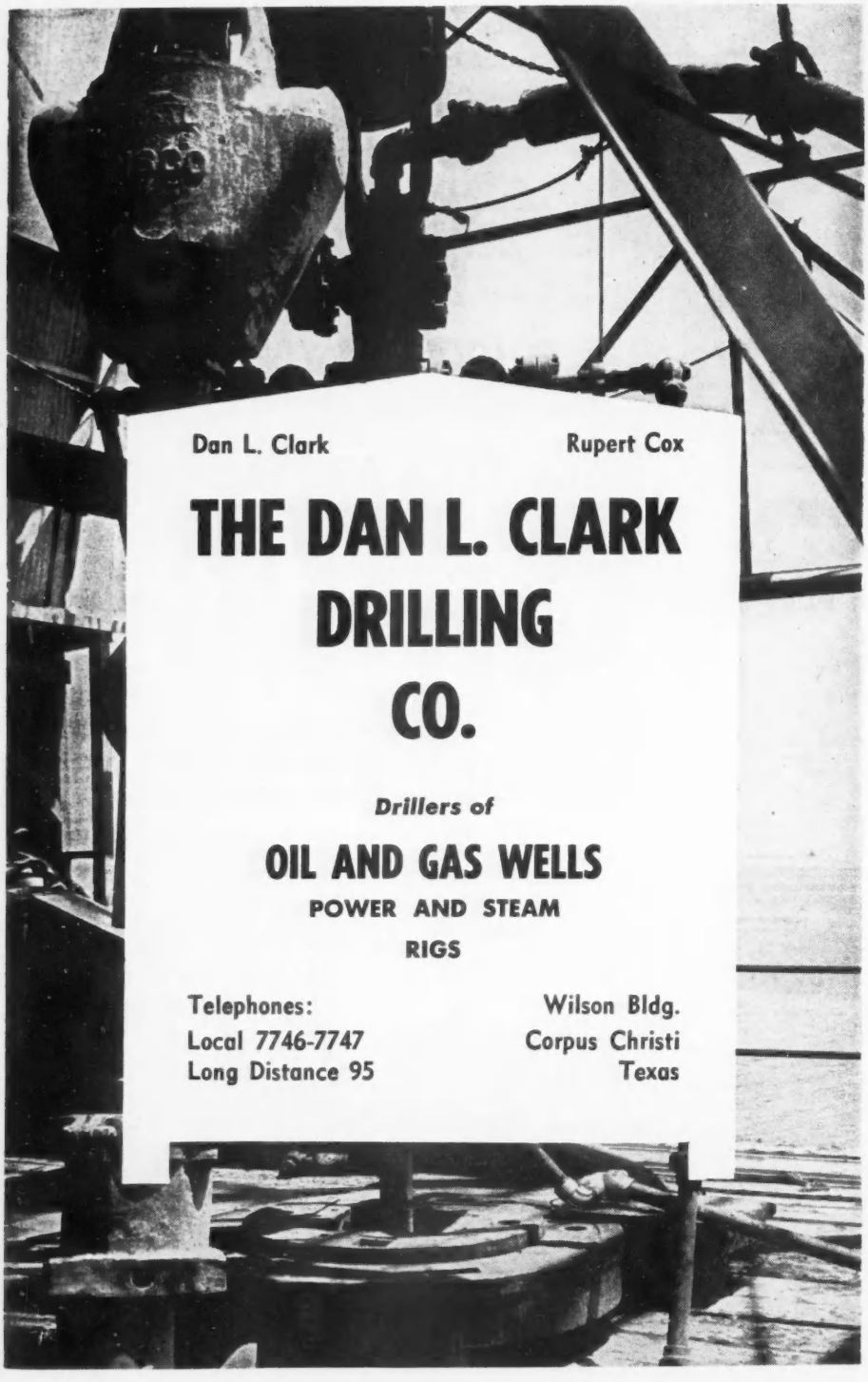
"Oil Well Drilling Products" is a new catalog containing descriptive and engineering data on oil emulsion and oil base muds, mud conditioning and lost circulation materials. The effects of Silvacon 100 on water loss from both oil emulsion and oil base muds are shown in table form. Properties of Silvatan, a quebracho-like additive, are presented along with suggestions for its use. Three lost circulation materials, Silvaflake, Superbridge, and Silvacel are also described and illustrated.

For a copy of this catalog, write Silvacon Products Department, Weyerhaeuser Timber Company, Longview, Wash.

Regulators

A new four-page folder gives useful information on temperature regulators, pressure regulators, and desuperheaters. A complete explanation of the principles of pilot-operated regulating valves is given in addition to data and illustrations of 27 Spence pilots.

For a copy of this folder, write Spence Engineering Company, Walden, N. Y.



Diesels

A new bulletin, No. 5296, contains complete specifications of HRBB-600 and HRBBI-600 Cummins diesels, which are specifically designed for use on automotive applications where there is need for the flexibility of higher rotative speeds and the performance of high horsepower.

For a copy of this bulletin, write Cummins Engine Company, Inc., Columbus, Indiana.

Remote Controls

Two series of hydraulic remote controls for industrial use, with available accessories, including intermediate transmitter for use at secondary control stations, are described in Bulletin 20-105.

For a copy of this bulletin write C. E. Hohl, Industrial Sales section, Sperry Products, Inc., Danbury, Conn.

Tank Erection

Facilities and services of the company, including tank erection, structural steel, industrial piping, floating roof, vessels, and miscellaneous construction, are covered in a new 12-page illustrated booklet.

For a copy of this booklet write Ellerbee Brothers, Port Arthur, Texas.

Micrometers

Bulletin R-3 presents a line of micrometers which has been simplified so that in the larger sizes one instrument will measure a greater range of dimensions. Details of external dimensions and information on selection of the correct micrometer are given.

For a copy of this bulletin, white Rimat Machine Tool Company, 1117 Air Way, Glendale 1, Calif.

Steam Traps

A 32-page illustrated catalog describes various types of thermostatic, expansion, and piston-operated steam traps; weight-operated traps; for steam, air, gasoline; and steam, air and gas separators. Capacity tables, installation diagrams, and charts for determining the proper size trap for specific applications are included.

For a copy of this catalog, write W. H. Nicholson & Company, 12 Oregon Street, Wilkes-Barre, Penn.

Cable Hoists

A new 8-page folder covers the line of Bob-Cat heavy-duty electric cable hoists. The bulletin, printed in 3 colors and illustrated with photographs, diagrams and line drawings, gives full descriptions, specifications, prices and ordering data on Ohio Bob-Cat hoists.

For a copy of this bulletin write The Ohio Electric Manufacturing Company, 5900 Maurice Avenue, Cleveland, Ohio.

NEW LITERATURE

V-Belt Drives

Three new booklets give information on V-belt drives. Bulletin MVD-1000, a 16-page illustrated booklet, gives dimensions and specifications on both sheaves and V-belts. Bulletin FHP-101 gives data and prices on V-belts for fractional horsepower, while Bulletin MV-201 covers multiple V-belts.

For copies of these booklets write Maurey Manufacturing Corporation, V-Drive Division, 2915 South Wabash Avenue, Chicago 16.

Plant Equipment

A new products list folder, entitled "Index of SK Equipment and Descriptive Bulletins," lists SK products according to application and alphabetically, together with the numbered descriptive bulletin pertaining to each product.

For a copy of this folder write Schutte and Koerting Company, 12th & Thompson Streets, Philadelphia 22.

Electric Logging Data

Fundamentals of electrical logging in easy-to-comprehend language plus illustrative diagrams are contained in a new brochure, "Widco Loggers." Applications of electric logs to geologic problems, investigation of water supplies, search for minerals, data for surface exploration and production problems are summarized. Engineering specifications and descriptions of the Widco logging units are presented.

For a copy of this brochure write Well Instrument Developing Company, P. O. Box 2406, Houston.

Materials Chart

The most economical material satisfactory for resistance to corrosive media can be determined with a new four-page folder, "Materials Selection Chart." The material most satisfactory for any of 350 corrosive conditions can be selected from the chart.

For a copy of this folder, write The Cooper Alloy Foundry Company, Hillside 5, N. J.

Tubing Spider

National Type "B" tubing spider and slip assembly, designed to accommodate all sizes of tubing in two sizes of assemblies, is fully described with illustrations in a new four-page bulletin, No. 367.

For a copy of this bulletin, write National Supply Company, Box 899A, Toledo, Ohio.

Flow-Line Valve

A semi-technical article on the Otis automatically-operating flow-line safety valve, written by C. A. Kizer, and development and service engineer at Otis, is contained in a new folder.

For a copy of this folder, write Otis Pressure Control, Inc., Box 7206, Dallas.

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Northern Louisiana & Mississippi
Ingersoll Corporation — Shreveport, Louisiana, and Jackson, Mississippi.

West Coast
Le Roi-Rix Machinery Co. — Los Angeles, Long Beach and Bakersfield, Calif.

Appalachian Area
P. C. McKenzie Co., Pittsburgh

Canada
Lucey Export Ltd. — Calgary, Edmonton, Alberta.

Men in the Industry NEWS

John M. Crawford

L. E. Whitehead

John M. Crawford, formerly superintendent of the Gravity division of the Geophysical department, Continental Oil Company, has been transferred to the development and research department, where, as supervising research geophysicist, he now heads the newly organized geophysical research division.

R. B. Sale

At the same time the Gravity and Seismic divisions of the Geophysical department have been designated as sections of newly created Operations division of the department, under **L. E. Whitehead**, superintendent. Whitehead formerly was superintendent of the Seismic division.

The Research and Development division of the geophysical department has been renamed the Equipment division, under the supervision of **Frank Searcy**, superintendent, and **R. F. Hughes**, assistant superintendent.

Crawford, a graduate of Phillips University and of the University of Oklahoma, joined Continental in 1934. Whitehead was graduated from the University of Kansas and came to Continental in 1927. Searcy obtained his degree at Oklahoma A. & M. College and entered Continental employment in 1931. Hughes is a graduate of the University of Oklahoma and joined Continental in 1933.

R. B. Sale, formerly assistant regional manager of Continental Oil Company's Production department, Ponca City, Okla., has been promoted to the newly-created position of director of training in the production department, with headquarters in Ponca City.

Sale received his early education at Shawnee, Okla., and later attended Oklahoma A. & M. College, Stillwater. He joined Continental as a clerk in 1926. Through various promotions Sale rose to assistant to the Ponca City region manager of production in 1943 and became assistant region manager in 1949.

•

W. B. Duckworth has been appointed Tax and Insurance Advisor for the Tulsa division of Gulf Oil Corporation, succeeding **J. D. Iams**, retired. Duckworth has been assistant advisor in the Tax and Insurance department for several years, and has been employed by Gulf for the past 31 years.

R. Ogarrio, vice president and director of The Texas Company, has resigned and will retire December 31. At that time Ogarrio will have completed 34 years of service with the company, which began in 1916 in the company's operations in Mexico. In 1925 he was appointed general manager of The Texas Petroleum Company, operating in Colombia and Venezuela. In 1928 he was elected vice president in charge of production, and in 1931 he was elected to the board of directors.

Ogarrio will establish residence in Mexico and will continue in a consulting and advisory capacity primarily on the company's foreign activities.

•

Robert L. Minckler, president of General Petroleum Corporation, Los Angeles, has been re-elected to the board of directors of the National Industrial Conference Board. Started in 1916, the Conference Board is a non-profit organization which is supported by more than 3000 business concerns, labor unions, trade associations, government bureaus, libraries, colleges and universities.

•

Jackson M. Barton, formerly director of exploration for the Cooperative Refinery Association in Kansas City, was appointed manager of Deep Rock Oil Corporation's Geological department.

John H. Jennings joined Deep Rock Oil Corporation's staff as evaluation engineer. He had been petroleum engineer for The Ohio Oil Company's Tulsa division for the past five years.

Barton received his B.S. degree from the University of Oklahoma in 1938, then worked for Magnolia Petroleum Company a year before continuing graduate studies at Yale. He returned to Magnolia in 1941 and served the company both in Oklahoma and West Texas for five years. In 1946, he joined the Cooperative Refinery Association as division geologist at Wichita, Kansas. Later he moved to Kansas City as chief geologist for Cooperative and was appointed director of exploration last September.

Jennings received his petroleum engineering degree from the University of Pittsburgh in 1939, and soon after started work with Sunray Oil Corporation in Tulsa. In 1942 he joined The Ohio Oil Company, and worked a year for the Mountain Fuel Supply Company at Rock Springs, Wyo., before being transferred to The Ohio's Bakersfield, Calif., division.

He left The Ohio in 1944 to do private consulting work, but in 1945 rejoined the company in Tulsa where he remained until the Deep Rock appointment.

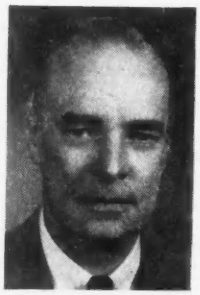
•

Harry A. Busten, Tulsa, has been named general traffic manager for Warren Petroleum Corporation, succeeding the late **N. A. Lindsay. Oscar U. Utz** has been named assistant traffic manager in charge of rates; **Ray E. Cramberg**, assistant in charge of LP-Gas transportation; **Douglas A. Collins**, assistant in charge of natural gasoline transportation; **H. G. Cosby**, assistant in charge of the Houston district.

Leslie A. Thompson

Donald Campbell

Donald Campbell, general counsel for Stanolind Oil and Gas Company since 1939, has retired and has been succeeded as general counsel by **Leslie A. Thompson**, formerly general attorney. **Wilbur W. Heard** replaces Thompson as general attorney.



Wilbur W. Heard

Campbell received his L.L.B. degree from the University of Michigan Law School in 1905, and practiced law in Montana until 1921, when he became attorney for a subsidiary of Standard Oil Company (Indiana). He remained with the company in Montana until 1933, when he moved to Tulsa to become a member of the Law department of Stanolind Oil and Gas Company. He was made assistant general attorney in 1934 and general attorney in 1939. Later, his title was changed to general counsel.

Thompson was with Midwest Refining Company from 1916 until 1931, when he joined the Stanolind Law department in Tulsa. He has been general attorney since July, 1947.

Heard has been with Stanolind since 1936, joining the firm at Lake Charles, La. In 1938, he transferred to Stanolind's Houston office, and in 1940 went to Tulsa as an attorney. In May of this year he was named assistant general attorney.

•

Delbert Y. Hewitt has been promoted to president of Leonard Pipe Line Company, Mt. Pleasant, Mich. **John J. Devine** has been advanced to vice president. **J. Walter Leonard**, organizer of the pipe line company and other affiliated producing and refining companies, continues as chairman of the board of Leonard Pipe Line.

Hewitt, associated with the purchasing and transporting branch of the oil industry for 20 years, joined Leonard in December, 1948, as executive vice president. Devine, with the company since 1938, and general manager since May, 1948, continues as general manager.

•

C. A. Prichard, president; **J. M. Clampitt**, vice president; and **Les Clampitt**, secretary-treasurer and manager, have organized Capitt Drilling, Inc., at Wichita, Kansas.

MEN IN THE INDUSTRY NEWS

Louis Roark has been appointed assistant manager and supervisor of land activity in Oklahoma, Kansas, Rocky Mountain area, Texas Panhandle and Northern Arkansas, under Sunray Oil Corporation's revised Land department setup, in which there are three operating divisions.

Carl Zwick will be division landman for Southwest Texas, Gulf Coast Texas, Louisiana, Mississippi, Alabama, Georgia, Florida, Southern Arkansas and East Texas; **Ish W. Pilkington** will be division landman for North and Central Texas and Southeast New Mexico. Landmen working out of the Tulsa office but covering all areas will be **Ed Parks** and **Frank C. Adams.**

Sunray's exploration activities in the Mid-Continent will be under the supervision of **E. A. Markley,** chief geologist, with **Marion J. Moore** and **Sherrill A. Shannon,** division geologists, working directly under him. Also working with Markley will be Sunray's geophysical department with **T. S. Green** directing the Midland, Abilene and Oklahoma City districts, and **Stefan Von Croy** directing the Shreveport, Lake Charles, San Antonio and Houston districts. **Thomas J. Thomas** will direct all gravity geophysical work.

Sunray's Land and Exploration district supervision and staffs are as follows:

Colorado: Denver—**Charles W. Sternberg,** district geologist and manager. Durango—**Robert L. Painter,** geologist.

Kansas: Wichita—**R. C. Lamb,** district geologist and manager; **Claude C. Winchell,** landman; **Don W. Rector,** scout; **Eugene E. Barr, Claude B. Kirby, Jr.,** and **Fred Lillibridge,** geologists.

Louisiana: Shreveport—**R. H. Alagood,** district geologist and manager; **W. Carlton Green,** landman; **Thomas W. Rich,** scout and assistant landman; **Harrell C. Stacy** and **Richard B. Sullivan, Jr.,** geologists. Lake Charles—**Bert C. Timm,** district geologist and manager; **Robert W. Mitchell,** landman; **Frank R. Hardin,** geologist.

Mississippi: Jackson — **Paul G. Potter,** landman and manager; **Lawrence J. Finfrocke,** geologist (working out of the Shreveport office).

Oklahoma: Tulsa (Eastern Oklahoma District)—**Thomas A. Clote,** district geologist and manager; **Douglas M. Smith,** scout; **Edward A. Hutchinson** and **Donald E. Luff,** geologists. Oklahoma City—**Thom H. Green,** district geologist and manager; **Ammon M. Wright,** landman; **Jack C. Felber,** scout; **Garret L. Boylard, Maurice H. Smith** and **Clifford Branan, Jr.,** geologists.

Texas: Abilene—**Wilford L. Stapp,** district geologist and manager; **Dewey Gibson,** landman (and available for all areas, presently working out of Cleburne). Midland—**E. A. McCullough,** district geologist and manager; **Carl E. Davis,** landman; **Karl F. Martin,** scout (military leave); **Reino Kangas,** geophysicist; **Robert O. Burkett, John L. Norris, Conrad S. Preston, Jess P. Roach** (military leave), **Melvin V. Smith, Edward V. Stone** and **Clarence Symes,** geologists. San Antonio—**Harold G. Picklesimer,** district geologist and manager; **Leroy C. Cockrell,** landman; **Thomas H. Terry, Jr.,** scout; **Landon Curry, Billy M. Easley, Jay R. Endicott, Jr., George E. Gosnell, Forrest M. McClain, Glenn W. Sandberg** and **Robert Staewen,** geologists. Houston—**John E. Tyson,** district geologist and manager.

Wyoming: Casper—**John S. Wold,** district geologist; **George E. Robertson,** landman; **Thomas W. Linds,** geologist.

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Jay E. Crane, a member of the board of directors of Standard Oil Company (N.J.) since 1944, was elected a vice president of the company. Crane's election follows the retirement of **R. T. Haslam**, a director and vice president. The number of Jersey vice presidents thus remains at four. Crane started in the banking business about the time international currency restrictions appeared, and soon was actively engaged in that field. He joined Jersey Standard in May, 1935, as assistant treasurer, after serving as a deputy governor of the Federal Reserve Bank of New York. In 1937 he became treasurer and served in that capacity until he was elected a member of the board of directors in 1944. He became a regular member of the Executive Committee in 1949.

Jay E. Crane

Haslam has joined **E. Holley Poe** and **Paul Ryan** as one of the principals of United States Pipe Line Company, and has been elected president and director.

•

Cyrus T. Helm has been elected executive vice president of International Petroleum Company, Ltd., an affiliate of Standard Oil Company (N. J.). Helm, who has had many years' experience in the oil business, particularly in Central and South America, was made a director of International in 1949. He has gone to Colombia and Peru in line with his new duties.

•

J. R. Maxey, former chief geophysicist, Deep Rock Oil Corporation, has entered the consulting business in Tulsa, specializing in review and evaluation of seismic and geological prospects.

•

Basil Kantzer, formerly manager of field operations for the Pacific Coast division of Union Oil Company of California, has been named manager of a newly-created Natural Gas and Gasoline department. Kantzer will be responsible for all matters concerning natural gas and its products, either produced by or purchased by the company.

Kenneth C. Vaughan, formerly division superintendent, Valley division, has been appointed manager of field operations, Pacific Coast division.

Kantzer joined Union Oil's Field department as roustabout at Santa Fe Springs in 1934 after graduation from Stanford University. In following years, he was a production engineer and production foreman at Santa Maria; district production foreman, Bakersfield; and chief production engineer in the Los Angeles head office.

A graduate of the University of Southern California, Vaughan joined Union Oil in 1933. Starting as a roustabout at Santa Fe Springs, he successively became a well puller and head well puller at Dominguez, assistant production foreman at Orcutt, Santa Fe Springs and Montebello. He was named maintenance foreman, Southern division in 1941; and thereafter became production foreman, Dominguez; production superintendent, Valley division; and production superintendent, Southern division.

Claude W. Pierce has been advanced to the new position of superintendent of water disposal for General Petroleum Corporation. He will work with the three production divisions in California on problems involved in the disposal of oil field wastes and the design and construction of injection plants for underground disposal of salt water. Pierce will maintain contact with public officials and regulatory bodies concerning waste disposal problems and will represent General Petroleum in oil industry committees handling waste water matters.

A veteran of 24 years with the company, Pierce has been resident engineer for the Production department's Southern division since 1942.

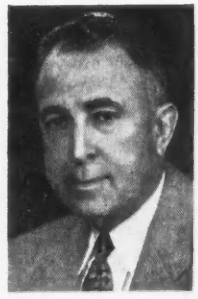
•

Robert L. Kelley has been appointed office manager of the Evansville, Ind., Production division of Sun Oil Company. He succeeds **Charles R. Perkins** who recently was elected secretary-treasurer of the Mid-Valley Pipe Line Company, Longview, Texas.

Kelley joined Sun Oil Company at Evansville in January, 1942, and moved up through various accounting subdivisions until his appointment as first assistant to the office manager in January of this year.

•

J. B. Harshman, formerly general manager of operations for Stanolind Pipe Line Company, has been named vice president in charge of H. C. Price Company's pipe line division, succeeding **J. P. Neill**, resigned, effective the first of 1951, to become an independent operator.



J. B. Harshman

Harshman moved to Oklahoma in 1920 and was employed by the Sinclair Pipe Line Company which later became the Stanolind Pipe Line Company. Starting out as an engineer in a pumping station he spent the ensuing 28 years in various capacities with Sinclair and Stanolind. During the past year and a half Harshman has been located in the east supervising construction operations on the New Jersey-New York end of the Transcontinental Gas Pipe Line Company project for Fish Constructors, Houston. His new headquarters will be in Bartlesville, Okla.

•

Joseph H. Himes, Washington, D. C., was elected chairman of the stockholders' committee of Pantepec Oil Company C. A., a Venezuelan corporation. He has been a member of the committee, which acts in an advisory capacity to the management, for a number of years.

Among Himes' numerous business connections in this country and abroad, he is a special partner of Merrill Lynch, Pierce, Fenner & Beane, and is president of the Blue Cross Hospitalization Plan and Joseph H. Himes Co. Inc., of Washington. He is also a director of Electric Boat Company, Acacia Mutual Life Insurance Company, Washington, and Canadair, Ltd., Montreal.

MEN IN THE INDUSTRY NEWS

L. E. Sloan, formerly district production superintendent at Pampa, Texas, will be in charge of Stanolind Oil and Gas Company's new district office at Abilene, Texas. The new office in the Joe Partin Building handles both exploration and production work for the North Central Texas area, the Panhandle and part of West Texas, and is under the North Texas-New Mexico division office managed by **John R. Evans.**

Other personnel at Abilene are **C. W. Baden**, transferred from Longview, Texas, as district clerk, and **J. B. Jenkins**, from Pampa, as district engineer. Exploration will be supervised by **H. S. Edwards**, district geologist, and **T. S. Yancey**, district landman. Both were formerly at Wichita Falls.

Stanolind has also set up a new area production office at Sweetwater, Texas, in the Allen Building. **J. O. Fair**, field superintendent, was formerly at Rangely, Colo. Also at Sweetwater are **F. M. Robertson**, field clerk, and **J. H. Larson**, field engineer.

Stanolind's district production office at Pampa and the district exploration office at Wichita Falls have been closed. The existing area office at Pampa will be enlarged to handle production activities in the Panhandle, and a geological sub-area office will be maintained at Wichita Falls.

•

Tom Pew, president of the General Crude Oil Company, has been made a member of the board of trustees of Cornell University.

•

Gayle P. Crawford has been named to the new post of assistant district geologist, West Texas-New Mexico district, Midland, Stanolind Oil and Gas Company. **Nugent T. Brasher, Charles R. Barr, Raymond A. Diemer** and **Jack A. Menish** will be area geologists.

•

Howard W. Benischek, assistant professor of petroleum engineering at Oklahoma University, Norman, Okla., has been appointed chairman of the University's School of Engineering, succeeding **Dr. John C. Calhoun**, resigned, and now head of the petroleum school of Pennsylvania State College.

•

Robert Stewart Bruns, Jr., has been elected a vice president of Transcontinental Gas Pipe Line Corporation, in charge of all phases of the corporation's Eastern operations.

A graduate mechanical engineer, Bruns was formerly with Preferred Utilities Manufacturing Company in an executive capacity.

•

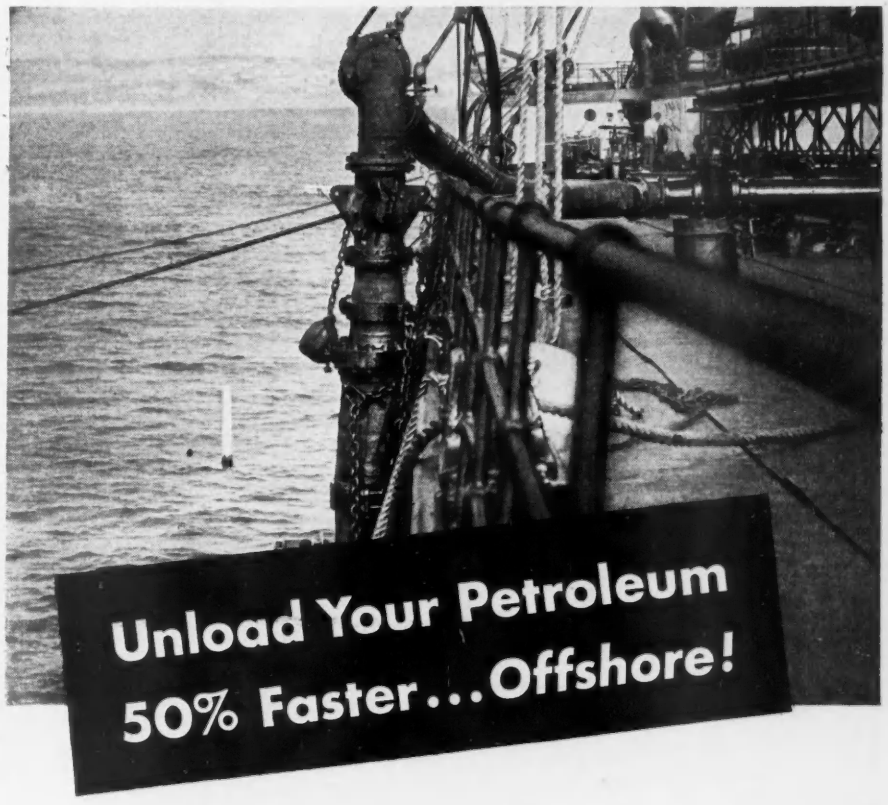
D. A. (Del) Howard has resigned as vice president of Republic Natural Gas Company, Dallas, to become an oil consultant with offices in Oklahoma City.

•

R. Denny Jackson has been named division geologist for Signal Oil and Gas Company at Midland, Texas.

•

George Darrow has resigned as geologist for Amerada Petroleum Corporation to become a consultant at Billings, Mont.



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Transfers and Promotions:

Gilbert W. Rice has been promoted to district foreman, Quitman district, for Pan American Pipe Line Company. In the Southern division, **Irving Spence** has been promoted to division mechanic with headquarters at Alvin, Texas. **Edward E. Livingston**, division mechanic of the Southern division, has moved to the West Texas division headquarters at Snyder. At Colorado City, West Texas division, **Hayne Nelms**, formerly headquartered at Longview, Texas, has been named chief station engineer in charge of the new main trunk line pumping station. **Milton Crow**, division superintendent of the West Texas division, has been transferred to the Northern division in the same capacity, and will headquarter at Longview. **V. T. Tracy**, formerly division superintendent in the Northern division, replaces Crow at Snyder. **S. L. Surratt**, division foreman at Longview, was transferred to division foreman in West Texas, where he will have jurisdiction primarily over the Kelly-Snyder area. **Lee May** was promoted from district foreman, Quitman district in East Texas, to division foreman with headquarters at Longview.

James T. Wamsley, landman, Union Oil Company, has been transferred from Great Falls, Mont., to Denver, succeeding **Max L. Campbell** who is now with Bell Petroleum Company in the Rocky Mountain area . . . **Clarence W. Hughes** has been named Denver Basin scout for The Carter Oil Company, with headquarters in Denver . . . **L. C. Cloos**, assistant chief clerk for Sohio Petroleum Company, has been transferred from Mt. Vernon, Ind., to Oklahoma City . . . **Ray M. Devero**, landman for Skelly Oil Company, has been transferred from Shreveport to Oklahoma City as division landman, succeeding **Barney Hays**, retired . . . **George G. Murphy**, scout, Atlantic Refining Company, has been transferred from Jackson, Miss., to Lake Charles, La. . . . **Leonard Knaffle** succeeds him at Jackson . . . **E. L. Fipps**, district geologist for Plymouth Oil Company, has been transferred to Midland, Texas. For the past few years he had charge of the company's Oklahoma City office and its work in Oklahoma and the Illinois Basin . . . **A. J. Montgomery**, Oklahoma City district geologist, Phillips Petroleum Company, has been transferred to the Bartlesville, Okla., headquarters and promoted to division geologist. **R. E. McMinnis** and **W. E. McMurty**, geologists, have been transferred from Shawnee, Okla., to Oklahoma City as district geologist and assistant district geologist, respectively.

James M. Kendrick, landman, Stanolind Oil and Gas Company, has been transferred from the Panhandle district office, Amarillo, Texas, to the West Texas district office, Midland. **A. L. Ackers**, Geological department, has been transferred from Tulsa to Fort Worth. **John E. Lang** has been named district engineer for Stanolind at the Big Horn-Landers office, Cody, Wyo., replacing **F. M. Stewart**, transferred to Tulsa. **Martin Hegglund** has been transferred from Houston to Casper as senior petroleum engineer . . . Gulf Oil Corporation's Geological department, Fort Worth Production division, made the following changes: promoted to assistant division geological supervisors were **H. Y. McClure, J. R. Crump** and **P. A. Grant. L. E. Warren** was named zone geologist at Midland, Texas, and **Y. B. Newsom** was transferred from Fort Worth to Amarillo as zone geologist. **H. E. Chandler**, formerly field examiner at Odessa, Texas, was named assistant employe relations adviser and transferred to Fort Worth. **H. Patrick Reardon**, formerly district petroleum engineer, was promoted to assistant division petroleum engineer. **C. L. Robinson**, formerly district petroleum engineer, was named assistant division traffic and transportation supervisor. **E. P. Van Zandt, Jr.**, has been named assistant to the division land supervisor.

J. H. Galloway, formerly district superintendent of the California district, Gulf Coast division, for Humble Oil & Refining Company, has been promoted to assistant division superintendent, West Texas division. **John S. Bell**, who was division petroleum engineer of the East Texas division, succeeds Galloway as superintendent of the California district. **Harry Pistole** became division petroleum engineer of the East Texas division replacing Bell, and **Fred N. Wise** was promoted to assistant division petroleum engineer, Gulf Coast division, replacing Pistole. **John N. Johnson**, assistant to **Henry Phillips**, president of Sinclair Oil and Gas Company, New York, has been transferred to Tulsa. **Cam-**

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LISTED ON CALGARY, TORONTO AND VANCOUVER
STOCK EXCHANGES—ALSO ON MONTREAL CURB MARKET

eron L. Cox, intermediate petroleum engineer, transferred from Lindsay, Okla., to Pharr, Texas; **Richard M. Kobdish,** transferred from Casper, Wyo., to Tulsa as staff engineer; **Stephen F. DeVore,** promoted to division engineer and transferred from Kiefer, Okla., to Casper; **Wyatt L. Sisson,** promoted to district foreman and transferred from Gainesville, Texas, to Kiefer; **E. J. Stevens,** promoted to assistant district foreman and transferred from Arp, Texas, to Gainesville; **Franklin A. Dillard,** district foreman, promoted from Bonita, Texas, to Wewoka, Okla.; **Raymond L. Losure,** promoted to assistant district foreman and transferred from Arp to Bonita; **Robert M. Irwin,** senior clerk, transferred from Bairoil, Wyo., to Tulsa.

Carroll F. Osterholtz, Shell Oil Company, has been named safety representative for the Illinois division, replacing **J. E. (Jesse) James,** transferred to Houston as safety representative for the Houston division. **A. E. Palmer** and **T. M. Gillilan,** Shell scouts, were transferred to Casper, Wyo., and Ardmore, Okla., respectively. **F. C. Buckwalter,** engineer, has been transferred from Nowata, Okla., to Oklahoma City. **F. T. Connolly,** Geological department, has beeen transferred from Houston to Oklahoma City. **George M. Meacham,** senior clerk, moved from Benton, Ill., to Oklahoma City. **Jerome D. Goodrich** transferred from Houston to Tulsa as chief, mechanical engineering, replacing **John E. Orrell,** assigned to regional staff.

•

Bert O. Meadowcroft has been appointed assistant to the employe relations advisor for the Production department of Gulf Oil Corporation, Pittsburgh.

Bert O. Meadowcroft

Meadowcroft was graduated from Allegheny College with a degree in chemistry in 1930. He joined Gulf in 1936, aided in organizing the Gulf Tourgide Bureau, and served as manager of that activity until joining the Advertising and Sales Promotion department four years later. In 1947 Meadowcroft transferred to the Employe Relations department, where he has been head of the Employment Unit.

Appointed to succeed Meadowcroft as head of the Employment Unit is **John F. Orend, Jr.,** former assistant head. Orend joined Gulf in the General Accounting department in 1937.

•

Jack Brown, vice president, Penguin Petroleum, Inc., Wichita, Kansas, has sold his interest in the company to **W. G. Talbott** and has opened offices as a consultant geologist and independent operator at Wichita.

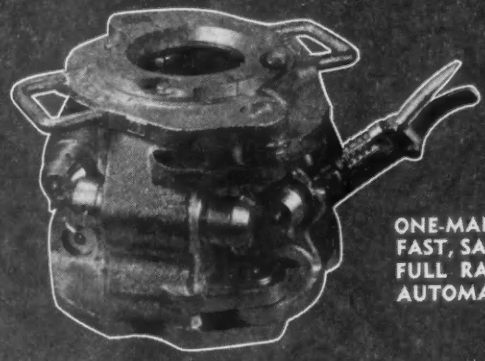
•

R. W. Biggart, geological consultant, has been named exploration geologist for Foundation Oil, Tulsa.

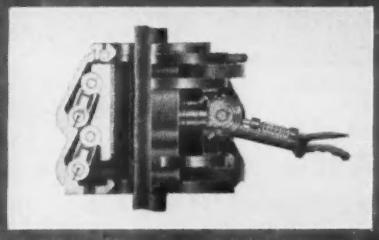
•

F. O. Mortlock has been named division geophysical supervisor for Fort Worth division, Gulf Oil Corporation.

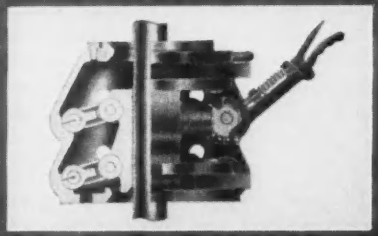
Increase Your Production Time
with the
KINZBACH
automatic tubing spider



ONE-MAN OPERATION
FAST, SAFE, POSITIVE GRIP
FULL RANGE
AUTOMATIC ALIGNMENT.



Running in. Slip segments are fully retracted



Slip Set. Note that slip segments are still parallel with the centerline of the pipe. Handle is locked in "closed" position.

This revolutionary development in Tubing Spiders, utilizes parallel-linkages to control the slip segments—a design which makes pipe handling faster and safer than ever before. The segments move at all times perfectly parallel with the tubing. The parallel slips provide a stronger grip than the conventional wedge design and will not gouge or score the tubing.

A single lever actuates the slips and they may be locked in either "open" or "closed" position. All segments are held in alignment with the tubing at all times and true radial closure is obtained.

The assembly is hinged and may be placed around the tubing without breaking a joint and may be used on wellhead fittings or set in the rotary bushing.

For complete information write for Bulletin 23151.

KINZBACH TOOL CO INC

KINZBACH TOOL CO., INC.
P. O. Box 277 Houston 1, Texas
Export Office: 74 Trinity Place, New York, N. Y.

Frank M. Porter, API president, was honored by his home town, Oklahoma City, when the board of directors and the Oil and Gas division of the Chamber of Commerce gave a dinner in his honor. **Tom Marshall,** chairman of the Oil and Gas division, presented Porter with an inscribed scroll expressing appreciation for his services to the oil industry.

•

George B. Randels, general superintendent, northern division, Interstate Oil Pipe Line Company, Tulsa, has been loaned to Interprovincial Pipe Line Company, Ltd., and will be located at Edmonton, Alberta. It is expected he will remain in Canada for about a year.

Howard C. Pyle has opened offices at 918 Pacific Finance Building, and 621 South Hope Street, Los Angeles, for the consulting practice of petroleum engineering and geology.

•

Dale Rogers, advertising manager for Mid-Continent Petroleum Corporation, Tulsa, has been elected first lieutenant governor of the 10th district, Advertising Federation of America.

•

Ewell F. Hindman has been appointed general manager of Louisiana Natural Gas Corporation. He joined the company in 1949 as pipe line superintendent.

What's your wall scraping job? Removing mud cake?...Increasing diameter for gravel packing? Cementing? *You can do the job faster and better —for less—with the Grant Hydraulic Expansion Wall Scraper!*

Its simple, rugged construction insures long, trouble free service. Blade expansion by pump pressure is controlled entirely from the rig floor. Seven scraper body sizes cover the range from 4¾" to 36". Three types—bull-nose, bottom hole and diamond point—will meet your specific scraping requirements.

Your nearby Grant branch is ready to furnish the Wall Scraper you want for your next job, and a service man stands ready to assist in running and operating the tool—day or night. *Call Grant—write direct for Bulletin 20 giving full details—or see the Grant Section in the Composite Catalog!*

Proven Grant Tools—Used Where Performance Counts

Hydrostatic Bailers	Bulletin No. 11
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Casing Scrapers	Bulletin No. 17
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Underreamers (Cable Tool)	Bulletin No. 27
Hole Enlargers	Bulletin No. 38
Reamers	Bulletin No. 43
Hydrostatic Perforation Cleaners	Bulletin No. 50
Dump Bailers	Bulletin No. 51
Roller Cutter Shale Bits	Bulletin No. 54
Sand Pumps	Bulletin No. 55
Well Cleanout Equipment	Bulletin No. 57
Wall and Bottom Hole Scrapers	Bulletin No. 58

Write for Descriptive Bulletins on these Grant Tools

GRANT OIL TOOL COMPANY

Main Office and Plant
2042 E. Vernon, Los Angeles 11, Calif.
Branches Throughout California and The Mid-Continent
Subsidiary: MacClatchie Manufacturing Company

William F. Davis, assistant to the northern division general superintendent, Interstate Oil Pipe Line Company, has been loaned to Lakehead Pipe Line Company, Inc., for approximately one year as assistant manager. Lakehead is a unit of Interprovincial Pipe Line Company.

•

Emil J. Senne of Baldwin, L. I., who retired in 1939 after 48 years with the Socony-Vacuum Oil Company, Inc., received a Certificate of Merit from the American Petroleum Institute for his efforts in accident prevention in Socony-Vacuum and throughout the oil industry. The presentation was at a meeting of the National Safety Council.

•

Hector Bassaizteguy of Uruguay is now attached to the Bureau of Mines Experiment Sation, Bartlesville, Okla., for a one-year in-service training period arranged between the U. S. Department of State and the government of Uruguay. He is a graduate of the University of Montevideo in industrial chemistry and will work at the Bureau as an employe.

•

George E. Link has resigned from Cooperative Refining to join the geological staff of Anderson-Prichard Oil Corporation at Wichita, Kansas.

•

Don Vaughn, formerly with the Oklahoma Conservation Department, has joined Bay Petroleum Corporation as geological draftsman.

•

Willis E. McCullough assumed the position of superintendent in the Santa Maria area succeeding Hollingsworth. Until this time McCullough has been production foreman on Signal's Santa Maria operations.

•

Gene W. Wetzel has resigned from the geological staff, Stanolind Oil and Gas Company, and is now a consulting geologist with offices at 1012 Leonhardt Building, Oklahoma City.

•

Dean C. Wellman has resigned from Shell Oil Company to open an office in the Rocky Mountains area for Derby Oil Company at Denver.

•

Fletcher B. Farrar has resigned from The Texas Company at Salem, Ill., and joined Joe Slivak and Son as general superintendent at Mount Vernon, Ill.

•

Ralph C. Graham, a veteran executive with the Tennessee Gas Transmission Company, was elected vice president by the board of directors.

Graham is also vice president of Sterling Oil & Gas Company, a subsidiary company of Tennessee Gas. He joined the Tennessee Gas Transmission Company on November 1, 1945 and was chief geologist for four years. Graham is a graduate petroleum engineer from the Missouri School of Mines and has been actively engaged in petroleum engineering since 1934.

Standardize on Standard

9 BIG STORES
CONVENIENTLY LOCATED

STANDARD pioneered in servicing the oil industry in the Gulf Coast. 9 big stores, completely stocked with the finest drilling and production equipment, are strategically located with respect to the active fields in this area . . .

Now comes the development of "off shore" Marine Drilling and you will find STANDARD on the ground, offering the same service that has earned the good will of operators throughout the entire Gulf Coast territory . . .

Houston has been selected as the location of our 9th branch store. Here you will find the most complete stock of drilling and production equipment and here you will receive the same co-operation and assistance in your production problems that have always characterized STANDARD service.

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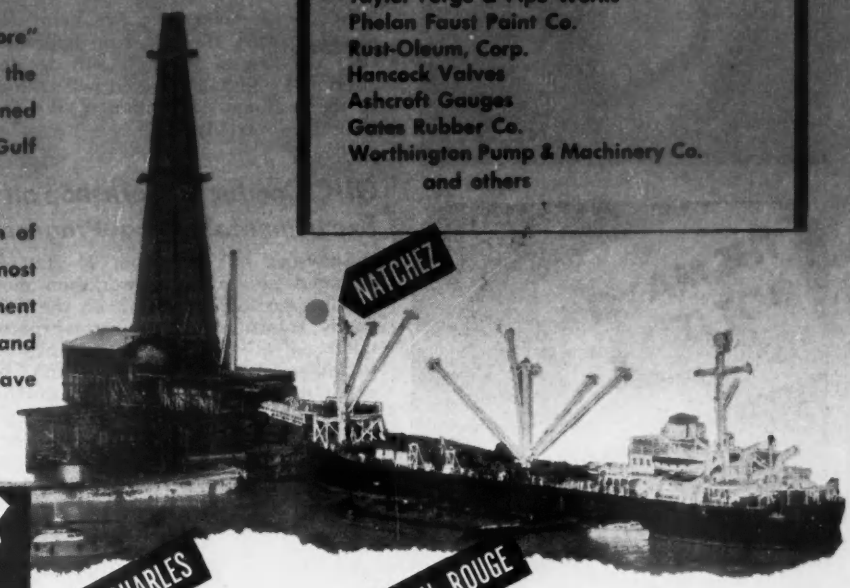
Rust-Oleum, Corp.
Hancock Valves
Ashcroft Gauges
Gates Rubber Co.
Worthington Pump & Machinery Co.
and others



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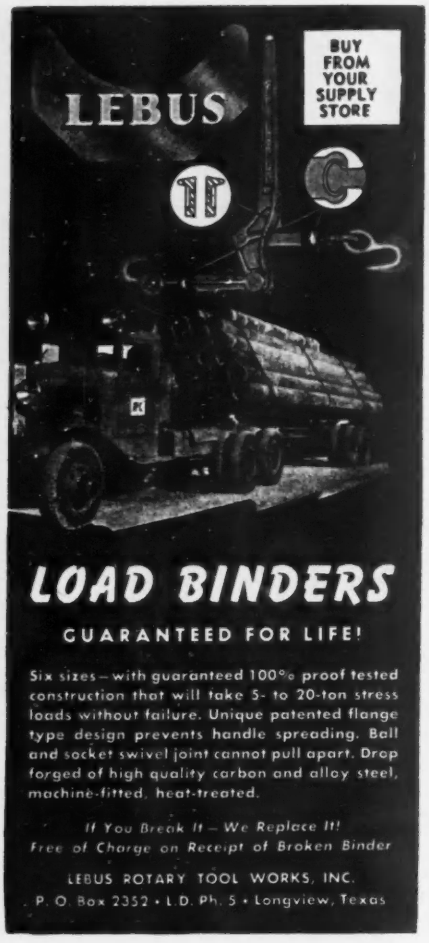
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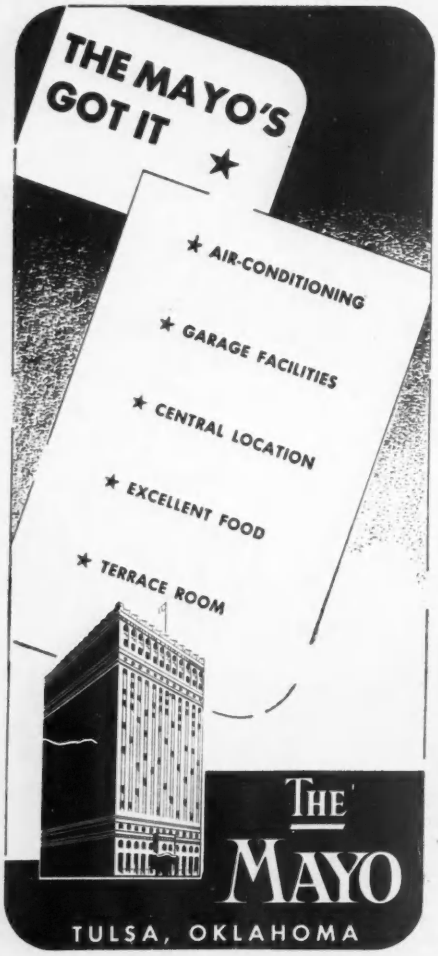


Associations

Executive Committee Nominees Named by Geophysicists Group

Candidates for its 1951-52 executive committee have been announced by the Society of Exploration Geophysicists, which now lists more than 2200 geophysicists from all over the world in its membership.

The nominees for president are Sigmund Hammer, Gulf Research and Development Company, Pittsburgh, and Sidon Harris, Southern Geophysical Company, Fort Worth. Nominees for vice president are Curtis H. Johnson, General Geophysical Corporation, San Marino, Calif.; and William W. Newton, of The Geotechnical Corporation, Dallas. Candidates for secretary-treasurer are E. D. Alcock, National Geophysical Company, Dallas; and Robert C. Dunlap, Jr., Geophysical Service, Inc., Bakersfield, Calif. Nominees for editor for 1951 to 1953 are Milton W. Dobrin of Magnolia Petroleum Company, Dallas; and Paul L. Lyons of The Carter Oil Company, Tulsa.

George E. Wagoner, president of the society, stated that a mail ballot taken after the first of the year will decide the election. Candidates elected will take office at the national convention of the society to be held next April.

OIIC Conducts Workshop on Experimental School Program

Sixty-five oil men from 21 states participated in a two-day workshop meeting in Chicago to begin work on the Oil Industry Information Committee experimental school program. The conference served to inform district, state, area and county committee members who will work with local high school teachers about the plan to give the schools in the 24 counties selected for the experimental program whatever special services they may need. Presiding over the meeting was Franklyn Waltman, of Philadelphia.

During the 1950-51 school year, local oil men in the 24 counties will work with the schools to provide distribution of teaching aid booklets, charts and other materials, as well as to arrange for educational tours of oil installations, talks and showings of industry movies.

API's Highest Award Goes To Former Jersey Chairman

Walter C. Teagle, former president and chairman of Standard Oil Company (N.J.), received the American Petroleum Institute's Gold Medal for Distinguished Achievement at the Institute's 30th Annual Meeting in Los Angeles.

Walter C. Teagle

The medal is regarded as one of the nation's foremost industrial awards. It was established in 1946 to pay special tribute to prominent Americans who have made outstanding contributions to public welfare through the petroleum industry. Previous recipients of the honor were J. Howard Pew, director and former president of Sun Oil Company; Dr. Charles F. Kettering, internationally-famed scientist; Dr. William Burton, former president of Standard Oil Company (Indiana), and the late Henry Ford.

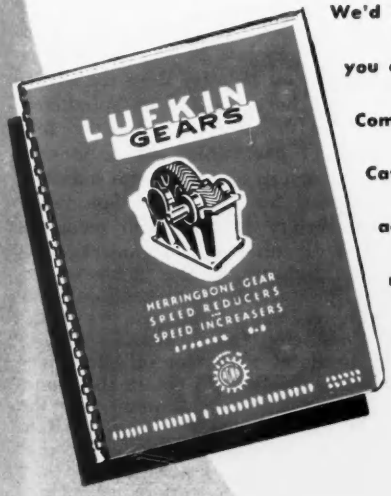
Teagle was the chief executive officer of Standard Oil Company (N. J.) for a quarter of a century beginning with World War I—the period of Standard's greatest growth. He also was one of the charter members and founders of the API in 1919. In addition to his duties as a Jersey Standard executive, Teagle contributed his services generously whenever the government needed him. He organized the Share-the-Work program for President Hoover. He headed the National Industrial Advisory Board, and was a member of the National Defense Mediation Board and the National War Labor Board, among other assignments.

Since his retirement, Teagle has maintained an office in the RCA building in New York, where he oversees the Teagle Foundation.

New Members of the Los Angeles Chapter of Nomads were inducted at a recent meeting. Shown receiving their shingles and pins from Ted Forsyth (left) are Sidney Shuman (center) of Fluid Packed Pump Company and Glenn Merley (right) of National Supply Company.

For the cost-minded thrifty . . . it's Lufkin in '50

COSTS . . . first costs . . . operating costs . . . . maintenance costs are going to be most important in the days ahead. Lufkin maintains that their equipment has the lowest operating and maintenance record in its field today. Our engineers will gladly give you the facts upon request to our nearest office. Why not investigate today?



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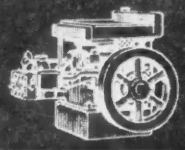
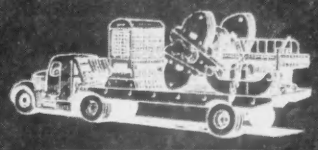
LUFKIN PUMPING UNITS •



LUFKIN-COOPER-BESSEMER ENGINES •



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INDUSTRIAL SPEED REDUCERS AND INCREASERS •

DIVISION LUFKIN FOUNDRY & MACHINE COMPANY
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Tubular Goods Supply Is Topic Of IOCC's Meeting in Houston

Regulatory Practices Committee of the Interstate Oil Compact Commission will study the oil field tubular material situation as it affects the conservation programs of the Compacting states at the Commission's Annual Meeting, December 11-13, in Houston.

Several prominent men have been asked to discuss this problem before the Committee by T. A. Morgan, Chairman, and A. W. Thompson, president of the AAODC, Houston, has accepted an invitation to present a paper on this subject at the Committee meeting.

Since an adequate supply of oil field tubular goods has become so important today to the drilling of oil and gas wells, the Committee by this project expects to develop the amount of material needed by the industry in order to carry on necessary operations and carry on the state conservation programs and to report their findings to the Commission.

TIPRO to Meet in March

Texas Independent Producers and Royalty Owners Association will hold its Fifth Annual Meeting March 27-28, 1951, in Beaumont, Texas.

First in

CANADA'S OIL FIELDS

Alberta today is one of the most active areas of oil exploration in the world with almost double the number of producing wells and output than a year ago. The Royal Bank, with 57 branches in Alberta, opened its branch in the oil field territory in Turner Valley in 1928 and followed with branches in Leduc, Devon and Redwater as development expanded. We know the oil fields and the men responsible for the development.

Our branches in Calgary and Edmonton can supply up-to-the-minute and factual information for operators, equipment manufacturers and all who seek sound advice on establishing connections in Western Canada.

If you have any interest in Canada's oil fields, address your enquiry to:

E. B. Durham, *Supervisor* The Royal Bank of Canada, Calgary, Alberta

We do not provide information on oil securities

THE ROYAL BANK OF CANADA

Over 735 branches in Canada, the West Indies, Central and South America. New York, London, and Paris. Head office, Montreal.

Canada's "Oil" Bank

ASSETS EXCEED $2,334,000,000

IPAA Appoints Economist as Assistant to Society President

Minor S. Jameson, Jr., who has been economist for the Independent Petroleum Association of America since 1937, has been named assistant to the president of the association. J. E. Warren, IPAA president, said the newly-created post was made necessary by increasing activity of the association and by the broader scope of independent oil industry problems. Warren said new assignments to Jameson will require frequent conferences in the office of the president in Midland, Texas, with Executive Vice President H. B. Fell, Ardmore, Okla., Executive Manager C. E. Buchner, Tulsa, and General Counsel Russell B. Brown in Washington, D. C., where Jameson is now located.

M. S. Jameson, Jr.

Jameson was graduated from Massachusetts Institute of Technology in 1934 with a degree in engineering and business administration. For three years following graduation he was in the Economics division of the Federal Trade Commission in Washington. Service with the U. S. army disrupted his duties with IPAA in 1942 when he enlisted as a private. He was discharged in 1945 with the rank of captain in the Fuels and Lubricants division. He then returned to the Washington office of IPAA where he has since been located.

Women in Oil Industry Will Be Honored at Spindletop

Recognition of the important part played by women in the oil industry will be given by the Spindletop 50th Anniversary Commission on January 10, 1951, at the main Spindletop observance program in Beaumont, Texas.

The Spindletop Commission, which was appointed by Governor Allan Shivers of Texas to commemorate 50 years of progress in the modern oil industry since the bringing in of the Lucas Gusher at Spindletop on January 10, 1901, will be the first group to ever pay public tribute to outstanding women in the petroleum industry.

This special feature of the Spindletop 50th Anniversary program will recognize women in executive and technical ranks of the oil industry in the fields of exploration, production, transportation, storage, refining, and marketing.

The Spindletop Commission is contacting the heads of all major oil companies and trade associations to obtain the names of all women who would qualify for the awards. These groups are being asked to supply the names, addresses, length of time connected with the industry, and a brief explanation of the type work being done.

The presentation of the various awards will be made on the night of January 10, 1951, at which time leaders of the petroleum and allied industries will gather to commemorate the impact of the Spindletop discovery on modern civilization.

Most Modern Drilling Engines In the Oil Fields

BUDA 2505 Series

Drilling Engines

and the "Fuecomizer Kit" gives you a choice of Fuel!

The Buda 2505 Series are DRILLER'S ENGINES... Designed for drilling, these powerful workhorses have the guts to stand up and take the tough service Drillers give their equipment.

The new BUDA 2505 Series Engines—6 and 8 cylinders, with or without blowers, gas or Diesel—can be quickly and easily converted from Diesel to gas or vice versa with the "Fuecomizer" Kit, a Buda development that permits you to choose the cheapest and handiest fuel.

Get the 2505 story from your Buda Oilfield Distributor.
Write for details and bulletins.
The Buda Company, Harvey, Ill.

Every 2505 Owner Receives the FUECOMIZER certificate. Ask for details.

BO-13

Wherever there's Oil there's BUDA

Engines . . . Parts . . . Service

Pacific Coast Geologists Elect Officers for Three Societies

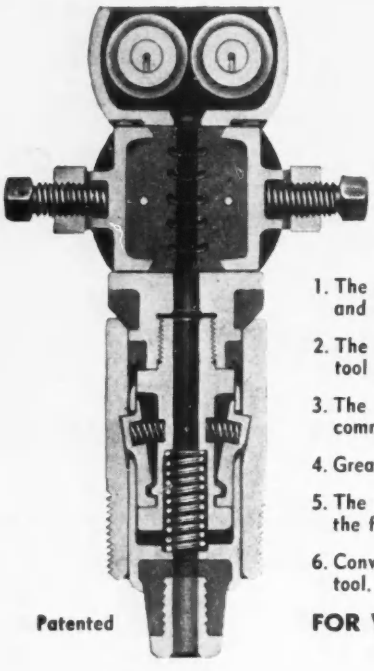
New officers were elected for the coming year at the joint meetings of the Pacific Coast sections of American Association of Petroleum Geologists, Society of Exploration Geophysicists and Society of Economic Paleontologists and Mineralogists. Approximately 700 persons attended the Los Angeles meetings.

The new AAPG president is Frank Carter, General Petroleum Corporation, Los Angeles; vice president, Frank Parker, Signal Oil and Gas Company, Los Angeles; and secretary-treasurer, Jack Knight, British-American Oil Producing Company, Los Angeles.

SEG officers are Robert Dyk, General Petroleum Corporation, Bakersfield, president; John Sloat, Union Oil Company of California, Bakersfield, vice president—northern district; F. H. Agee, United Geophysical Company, Pasadena, vice president—southern district; and O. K. Fuller, Humble Oil & Refining Company, Los Angeles, secretary-treasurer.

L. J. Simon of The Texas Company is president of SEPM, and Douglas Crawford of Union Oil is secretary-treasurer. Both are of Los Angeles.

Low Maintenance
LOW COST—LONG LIFE



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With A 3AR Wire Line STRIPPER FOR SWABBING TUBING

Type 3AR King Wire Line Stripper ("Oil Saver") is the ideal tool to use in connection with swabbing operations.

1. The positive latch and sure release insure against accidents and eliminate the possibility of jerking a wire line in two.
2. The packing is inserted from the sides of the tool and the tool can be repacked while the line is in the hole.
3. The roller line guides center the line; outlasts the more commonly used bushing many times.
4. Grease nipples are provided to lubricate the guide rollers.
5. The non-sparking materials used in its construction minimize the fire hazard.
6. Convenient hand holds contribute to easy handling of the tool.

Patented

FOR WIRE LINE CORING THE 4AR KING WIRE LINE STRIPPER IS WIDELY USED

The Type 4AR Stripper is similar to the Type 3AR, except it is a little larger. It is commonly used in connection with the Type 4C King Circulating Head. It can be, and sometimes is, used with other makes of circulating heads.

These tools are constantly coming into greater use. A trial is convincing.

All prices F.O.B. Houston, Texas, and subject to change without notice.

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See your Composite Catalog for detailed description of other King Tools

KING OIL TOOLS
210 TERMINAL STREET PHONE WO-8013
HOUSTON 20, TEXAS

Western Oil and Gas Society Appoints Public Relations Man

Arthur M. McQuiddy, former executive secretary of the New Mexico Oil and Gas Association, has joined the staff of the Western Oil and Gas Association as a public relations field representative. He will coordinate the activities of the more than 100 area committees organized in connection with the Association's "grass roots" public relations program in the five western states, it was announced by John M. Peirce, vice president and general manager of the Association.

A. M. McQuiddy

Prior to joining the New Mexico Oil and Gas Association, where he served as executive secretary for three years, McQuiddy had been editor of the Roswell, N. M., *Morning Dispatch*. He formerly worked for the Associated Press in Kansas City and for the Kansas City Star.

NACE Plans 1951 Conference And Exhibition in New York

The 1951 Conference and Exhibition of the National Association of Corrosion Engineers will be held at the Statler Hotel, New York City, on March 13-16, it was announced by L. B. Donovan, Consolidated Edison Company, New York, chairman of the General Conference Committee.

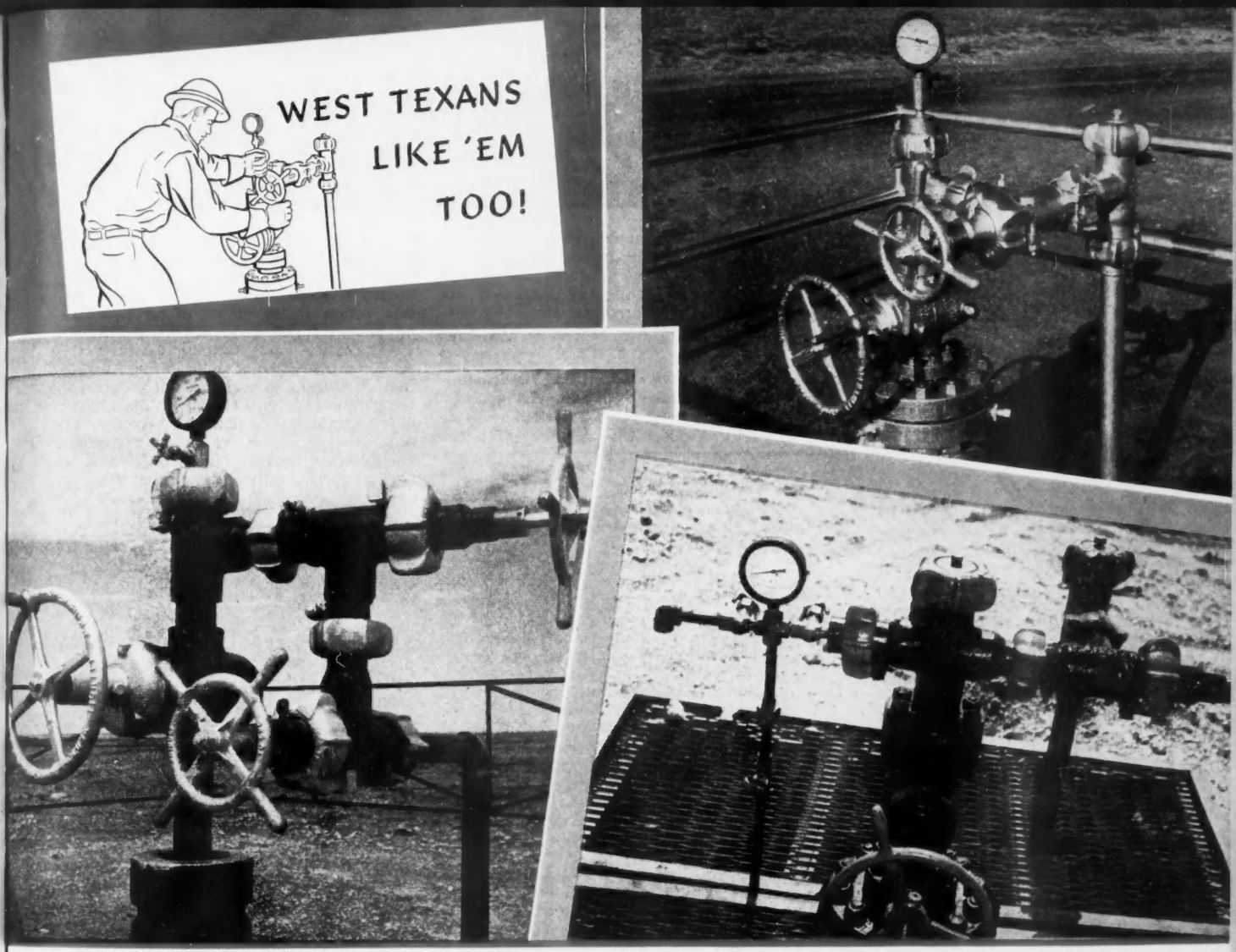
Dr. Norman Hackerman, Department of Chemistry, the University of Texas, is chairman of the Technical Program Committee. Among the other officers for the Technical Program are S. S. Smith, Shell Oil Company, New York, chairman of Pipe Line Industry Symposium; Kenneth Tator, Kenneth Tator Associates, Corapolis, Penn., chairman of Protective Coatings Symposium; T. S. Zajac, Shell, Houston, chairman of Oil and Gas Industry Symposium; Aaron Wachter, Shell Development Company, Emeryville, Calif., chairman of Symposium on Industrial Use of Corrosion Inhibitors; F. L. LaQue, International Nickel Company, Inc., New York, chairman of Round Table on General Corrosion Problems; and R. L. Bullock, Interstate Pipe Line Company, Tulsa, chairman of Round Table on Pipe Line and Underground Corrosion.

Pacific AIME Elects

Basil Kantzer, Union Oil Company of California, was elected to serve as chairman for the coming year of the Pacific Petroleum Chapter of the American Institute of Mining and Metallurgical Engineers.

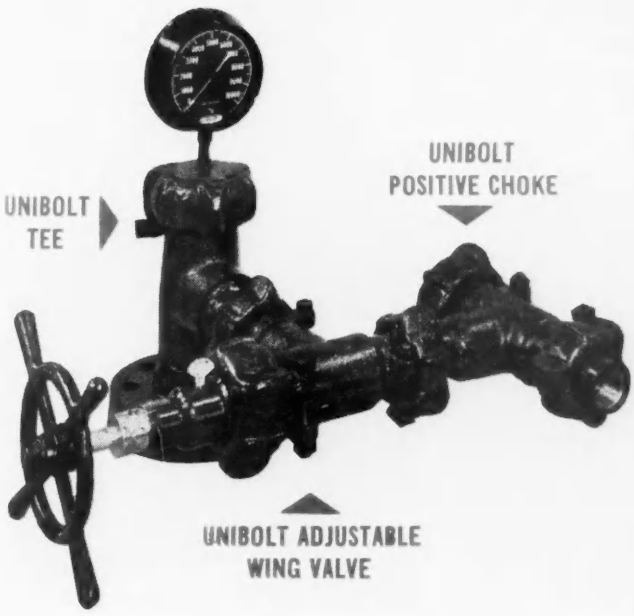
Shreveport Purchasers Elect

Dave Cowden, purchasing agent, Arkansas-Louisiana Gas Company, Shreveport, has been elected president of the Shreveport Purchasing Agents Association, succeeding the late Roy Reeder.



Views from Scurry, County, Texas

UNIBOLT *Flow Manifolds*



More and more operators are requesting their Christmas tree supplier to furnish UNIBOLT Flow Manifolds because they are lighter in weight, stronger, and more economical, and easier to maintain than ordinary flanged Christmas tree wings.

Employing standard UNIBOLT connections rather than flanges, the UNIBOLT Flow Manifold is many pounds lighter, yet the UNIBOLT design, which places more steel in shear, actually results in a higher factor of safety for the manifold.

The units of the manifold — UNIBOLT Tee or Cross, Adjustable Wing Valve, and Positive Choke Body — are pressure-tested as a unit and may be assembled in a number of combinations to best meet individual needs. They are furnished in regular forged steel or in high-chrome alloy for corrosive wells — 6,000, 10,000 and 15,000 lbs. test. The manifold is completely salvageable.

Any desired volume of well flow may be accurately produced with UNIBOLT Flow-Rated Beans, which are available in flow increments of 5% and 10%, or in standard fractionally drilled sizes. See your Composite Catalog for complete details or write for literature.

THORNHILL-CRAVER COMPANY UNIBOLT **HOUSTON, TEXAS**

Companies in the News

UNION OIL COMPANY OF CALIFORNIA, celebrating its 60th anniversary, paid special honor to employes who have been with the firm for 35 years or more. In citing the growth of the company, President Reese H. Taylor pointed out that when Union Oil was organized at Santa Paula, Calif., October 17, 1890, there were less than 100 employes on the payrolls of the three firms which merged to found the new company. That first year, 85,000 barrels of crude were produced. Today, Union has 7200 employes, produces 26 million barrels a year, and has increased its proved reserves to approximately 600 million barrels.

•

GULF OIL CORPORATION is assisting in the establishment of a chair of geology at the American University of Beirut, Republic of Lebanon, beginning with the 1950 fall term, according to an announcement by **Dr. K. C. Heald**, Gulf vice president. Dr. Heald said that Gulf was taking this action in an effort to advance the establishment of good will between the U. S. and Lebanon, thus furthering President Truman's Point Four Program. **Dr. Roy A. Wilson**, a geologist with Gulf, has been dispatched to Lebanon to occupy the chair. Dr. Wilson will teach three courses; physical geography, engineering geology and physical geology, all of which will be new subjects for the Beirut institution.

•

TEXAS GAS TRANSMISSION CORPORATION'S annual report for 1949 was voted the best in the natural gas industry by Judges for the Financial World Survey of Annual Reports.

•

SERVICE PIPE LINE COMPANY opened its new Tulsa headquarters building with ceremonies attended by leaders in the oil and transportation industries. Incorporating the most advanced construction techniques, the building is headquarters for a crude oil pipe line system that employs 2600 persons in ten states, gathers crude oil in mid-west, southwest and Rocky Mountain production areas and serves 37 refineries.

J. L. Burke

J. L. Burke, president, stated the new building is the only general office building in the country owned and entirely occupied by a common carrier pipe line company.

Service has been given the National Safety Council's Award of Honor for Distinguished Service to Safety for the second time since the award was originated. **Clyde Reeves**, president, and **Glenn Carmichael**, secretary, Oklahoma Safety Council, Oklahoma City, made the presentation which was accepted on behalf of the company by Burke.

Service Pipe Line's new Tulsa quarters.

In the American Tradition

PRESERVE YOUR FREEDOM!

Two men were crossing the ocean together. One rushed up to the other and wildly cried, "Jack, Jack, we've sprung a leak! The boat is sinking!" Jack answered, "Whadda I care! I don't own the boat."

There are too many "Jacks" in America who, by passive neglect, would let business sink. Business is our boat. We are all in it together. Anything that sinks it will destroy our way of life. Enough sunken businesses will mean government control . . . and drowning for all of us in the ocean of Socialism.

We who love freedom have a big job. Part of that job is to broadcast the truth about business and profits. For it was *successful* business that gave our country its high standard of living—business that made a profit on which to thrive and grow. Growing business gave more jobs to more workers—lowered costs . . . raised wages . . . paid more taxes to provide better schools, roads and bridges . . . reinvested in more efficient equipment with which to grow even larger and repeat the cycle of improvement.

When profit ceases, jobs come to an end. Business grinds to a halt. America is weakened.

Let's show all the "Jacks" why they should plug such potential leaks!

Use SPANG Weldless JARS
for
- Minimum footage costs
- Minimum fishing time loss
- Maximum strength, safety, durability, economy

The HIGHER STANDARD

SPANG CABLE TOOLS
made by
SPANG & CO.
BUTLER, PA.
for
OIL WELLS • GAS WELLS • ARTESIAN WELLS
SHOT BLAST HOLES • PROSPECT DRILLING

SPECIFY SPANG—FOR SALE BY DEALERS EVERYWHERE

EQUIPMENT AND SERVICE SUPPLIERS' NOTES

Emsco Derrick & Equipment Selects Pacific Manager, Chief Engineer

L. G. Evans

D. A. Carnahan

D. A. (Dave) Carnahan has been appointed sales manager in the Pacific Coast states for Emsco Derrick & Equipment Company. He is in charge of all Emsco sales in this area excluding those of the D+B division. He was formerly chief engineer of the D+B division.

Taking Carnahan's place as chief engineer for the entire D+B division is L. G. (Les) Evans. Evans joined the company in 1940, and prior to his present appointment was assistant manager of the D+B field store in California and assistant California sales manager for D+B.

Oil Men and State Officials Attend Dallas First National Celebration

Joining in dual celebration of the 75th anniversary of the First National Bank in Dallas and of their many years of business relations, more than 1000 oil men, government dignitaries, and bankers met for an evening of entertainment.

Setting the theme of the occasion, Eugene McElvaney, vice president in charge of the First National's Oil department and toastmaster for the evening, declared, "When an institution reaches its 75th anniversary, it is a pretty good place to pay tribute in all humility to those who have made you great."

Among those present to share in the celebration of the First National's 75th anniversary were: Governor Allan Shivers, Senator Tom Connally, Representatives Ed Gossett and Ken Regan; Frank M. Porter, president of the American Petroleum Institute; Robert Anderson, president of Texas Mid-Continent Oil & Gas Association; Jake Hamon, president of Mid-Continent Oil & Gas Association; Ed Warren, president of the Independent Petroleum Association of America; D. A. Hulcy, president of American Gas Association; A. W. Thompson, president of the American Association of Oilwell Drilling Contractors; R. L. Foree, president of the Texas Independent Producers & Royalty Owners Association, and Elliott V. Bell, publisher and editor of Business Week.

Nathan Adams, honorary chairman of the board and the guiding hand of the First National for the better part of its 75 years, was introduced. It was Adams who instituted the First National's policy of loaning money on oil that is still below the ground. The first loan following this principle was made in 1932 in the amount of $50,000; since then the First National has loaned more than $1 billion to the men of the nation's oil and gas business.

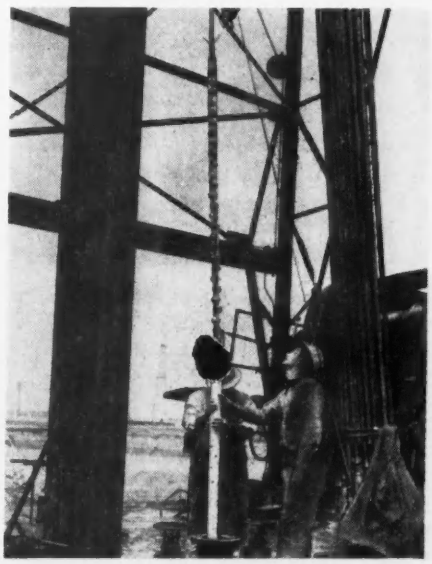
McCullough Glass Jet Perforator Is Tested at California Location

An unusual test of the new McCullough Tool Company's Glass Jet Perforator in an aluminum strip carrier was recently conducted near Yorba Linda, Calif. The test, requested by a major oil company, was held at the Hathaway Company's Kammerdiner 1 at East Coyote. Well temperature was 160° F., fluid level 2420 feet, shooting depth 2535 feet, pipe size 5-inch O.D. 17.70 pound J-55 liner.

Observed by engineers of the oil company, the test was made primarily to ascertain if any debris would be left in the hole from the aluminum strip; and if part of the jet charges should fail to fire would these unfired charges be left in the hole?

Forty shots of 3-inch O.D. Glass Jet units were mounted in an aluminum strip carrier. The prima-cord, initiator that detonates the shaped charge, was intentionally cut off immediately below the eighth charge to prevent the top eight shots from firing, so that results of a partially fired gun could be observed. The gun was run into the well to 2535 feet and fired. Examination at the surface showed the 32 bottom charges had fired, the upper eight charges were unfired. On further examination, it was found that the three charges closest to the shot charges were broken, the remaining five charges were still in perfect condition.

The aluminum strip carrier was retrieved intact but split evenly down the center section. The lower section below the 40 charges was unmarred. No metal debris was left in the hole.



McCullough Glass Jet Perforator being lowered into the well during the test conducted near Yorba Linda, Calif. Note collar finder fingers at top of assembly and plaster sinker bar. Sinker bars are now being made of lead for added weight and stability. The lead sinker bar is attached to the aluminum strip carrier and is retrieved from the well with the carrier.

Ideco Columbus Division Manager Retires, Successor Is Appointed

C. Edwin Ponkey

Ferguson Barnes

Ferguson Barnes has resigned as vice president and general manager of the Columbus division, International Derrick and Equipment Company. He is succeeded as general manager of the Columbus division by C. Edwin Ponkey, formerly vice president of the Sheldrick Manufacturing Corporation.

Before joining Ideco in 1938, Barnes was manager of the Coal Preparation department of Jeffery Manufacturing Company. Ponkey had been with Ex-Cello-O Corporation 20 years before he joined Sheldrick.

Reed's Cleco Division Appoints Distributor for Northern District

The Cleco Division of Reed Roller Bit Company, Houston, has appointed Granite City Tool Company, Box 368, St. Cloud, Minn., as distributor of Cleco products in that area. In addition to handling the full line of Cleco pneumatic tools, Granite City Tool Company will maintain complete stocks of Cleco parts and accessories for the convenience of customers in the St. Cloud area. The Cleco line includes tools for construction, manufacturing, metal fabrication, foundries and industrial maintenance.

Daily Houston-to-Caracas Flight Planned by Chicago & Southern Line

The oil fields of the Southwest and Venezuela will be connected December 15 by 300-miles-per-hour air service when Chicago & Southern Air Lines begins daily flights with its new 57-passenger Constellation airliners.

The airline has been using slower DC-4 aircraft on its international routes since July 31, 1948, when it extended its overseas service to Caracas.

Most other airlines entering Houston will provide connecting service to Chicago & Southern's daily non-stop flight to New Orleans where international passengers are transferred to the Constellation bound for South America. The flight will leave Houston at 4:15 p.m. and depart from New Orleans at 7:30 p.m. Arrival in Caracas is scheduled for 7 a.m. the following morning after enroute stops at Havana, Cuba, and Kingston, Jamaica. The return Constellation will leave Caracas at 9:30 a.m., arrive New Orleans at 5 p.m. and terminate at Houston at 8:42 p.m.

Tube Turns of Canada Appoints Williams Western Area Manager

Wayne E. Williams has been appointed Western district manager for Tube Turns of Canada Limited. His office is at 110 Clark Building, Edmonton, Alberta.

Wayne E. Williams

Williams majored in engineering at the University of Southern California. He has had 20 years of experience in the petroleum, chemical and power fields, and formerly was associated with C. F. Braun & Company and the W. M. Barnes Company, Ltd. For the past two years he was project engineer for the erection of a major refinery at Antwerp for the Raffinerie Belge de Petroles.

Oil Well Manufacturing Appoints Sales Manager for Specialty Line

Oil Well Manufacturing Corporation, Los Angeles, has appointed Carroll R. Baker to the post of sales manager for all Red Devil oil field specialties, expendable parts for slush pumps, and pump maintenance tools.

Baker is a graduate of Cal Tech and for 14 years served in several capacities for Oil Well Supply Company. In Texas and Louisiana, he was a field engineer. During the war, he was moved to Oil City, Penn., as an expeditor on war contracts. For the past seven years, he was in the New York export office, quotation department for four years, and division engineer three years.

National Supply Company Promotes Myers and Sowle at Torrance Plant

The National Supply Company, Torrance, Calif., has appointed Corbin H. Myers as superintendent of industrial engineering at National Supply's Torrance plant. The company also announced that David M. Sowle has been made superintendent of industrial relations, also at Torrance.

Myers, a graduate of the University of Cincinnati, joined National Supply in 1947 as an industrial engineer after several years experience in the industrial engineering field. Prior to his recent appointment he was supervisor of the Standards department.

Sowle attended the University of Wisconsin and the University of California. He was employed at National Supply's Torrance plant in 1946 as an industrial relations analyst and was promoted to employment manager in 1948.

Crews Operate in Venezuela

United Geophysical Company, S. A., has placed two structural core drilling rigs and one seismic crew in Venezuela for Venezuelan-Atlantic Refining Company, on temporary assignment.

ONE Pumping Unit Pumps TWO Wells

Pumping oil out of two wells at once from depths of 1250 feet is the job of this versatile Wisconsin Engine-powered unit, which slows to as few as 14 strokes a minute. The Wisconsin Heavy-Duty Air-Cooled Engine mounts a clutch-reduction assembly and operates on natural gas.

Builders of oil field equipment who know Wisconsin Engines "prove out" on *all jobs*, and users who see them "prove out" on *each job* specify and buy them because of features that assure maximum service with a minimum of servicing. Fool-proof any-climate air-cooling . . . tapered roller bearings at both ends of the crankshaft, taking up all thrusts . . . an OUTSIDE magneto with impulse coupling, for quick starting, summer and winter, are features that provide more trouble-free machine hours *gained on the job*, with less man-hours *lost in servicing*.

4-cycle single-cylinder, 2-cylinder, and V-type 4-cylinder models, 3 to 30 hp.

WISCONSIN MOTOR Corporation
MILWAUKEE 46, WISCONSIN
World's Largest Builders of Heavy-Duty Air-Cooled Engines

WRITE TO HARLEY SALES CO.
510 ATLAS BUILDING, TULSA, OKLAHOMA
M & M BUILDING, HOUSTON, TEXAS
505 SOUTH MAIN ST., WICHITA, KANSAS
OIL FIELD DISTRIBUTORS FOR WISCONSIN ENGINES AND ALL TYPES OF UTILITY UNITS.

West Texas District Supervisor Appointed by General Geophysical

John Daly, former Honolulu Oil Corporation seismologist, has been named supervisor of the West Texas District for General Geophysical Company and will make his headquarters in Midland, Texas.

John Daly

Daly has been in charge of seismograph work in West Texas, New Mexico, Colorado and Mississippi for Honolulu Oil Corporation. A graduate of California Institute of Technology with a B.S. degree in science and a M.S. degree in geology and paleontology, Daly has also worked for International Geophysics, Inc., and Shell Oil Company as seismologist and geologist.

H. K. Porter Company Acquires Birmingham Steel Producing Plant

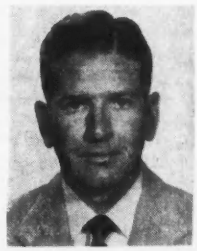
In a move to further diversify its manufacturing operations, H. K. Porter Company, Inc., Pittsburgh, has acquired Connors Steel Company, Inc., of Birmingham, Ala., producers of electric furnace steel and steel products.

The Connors company produces steel billets from scrap and operates a series of rolling mills to manufacture finished products.

The plant's total capacity exceeds 94,000 tons yearly.

Sales Engineer to South America For Fluid Packed Pump Company

John Brennan, Fluid Packed Pump Company sales engineer, is in Venezuela on a two-month business trip. He is headquartering in Maracaibo. While in South America, Brennan will assist National Supply Company of Venezuela personnel in Eastern Venezuela.



John Brennan

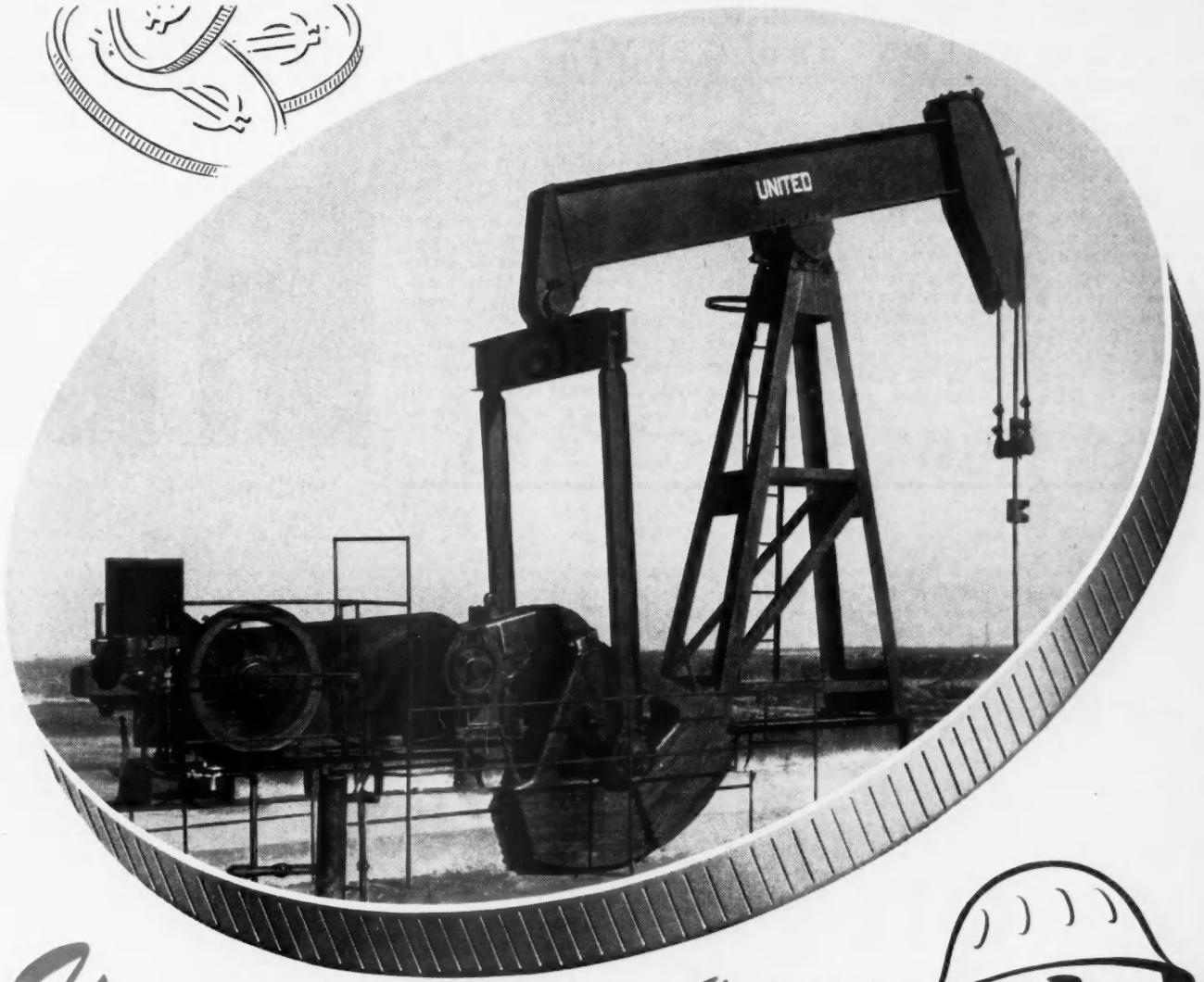
National Supply Company of Venezuela recently built a down-well pump service shop at Las Marchus, Venezuela, for servicing Oilmaster pumps.

Division and District Managers Named by United Supply Company

John L. Smith has been named division manager of United Supply and Manufacturing Company's West Texas area, with headquarters in Midland, Texas. He was promoted from district manager.

New district manager of the southern area of West Texas is Roger Northrup, who will also headquarter in Midland. He was formerly assistant district manager.

Northern area district manager is L. W. Moore, whose headquarters are in Hobbs, New Mexico.



Uncle Sandy...

Use UNITED PUMPING UNITS

Cut maintenance costs! Dollars invested in these units will pay dividends in longer, better, less costly service. Here's why: The United lubrication system is engineered to reduce man-hours of servicing — working parts in gear box and the center bearing assembly are oil bath lubricated, each bearing equipped with oil reservoir for immediate lubrication on starting. Gear box easily cleaned. Settling chamber can be drained separately. Torque ratings well over API classification. Oversize bearings to handle unforeseen overload. Welded structural members stand up under years of strain and vibration without attention. First Cost and Last Cost — UNITED PUMPING UNITS give more service per dollar!

Courtesy
Service
Dependability

UNITED SUPPLY
AND *Manufacturing* COMPANY
TULSA, OKLAHOMA
Stores in Kansas, Oklahoma, Texas,
Louisiana, and New Mexico

Core Lab and Oil Base Terminate Sales Distributorship Agreement

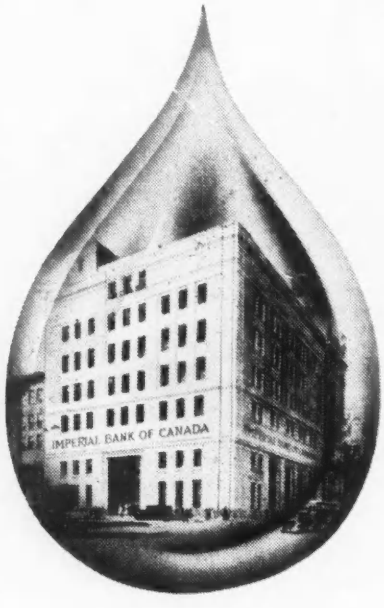
In a joint statement released from Dallas, Texas, and Compton, Calif., Core Laboratories, Inc., and Oil Base, Inc., announced the completion of a sales and service arrangement made between the two firms last year. Core Lab terminated its distribution of oil base and emulsion drilling fluids and related products on November 1, 1950, in order to concentrate field personnel efforts and facilities solely on petroleum reservoir engineering services, according to John D. Wisenbaker, president.

George Miller, president of Oil Base, Inc., stated that the distributorship formerly held by Core Lab east of California, including Canada, will be retained and operated by Oil Base, Inc. Tentative plans call for the location of a Mid-Continent general sales office in Fort Worth, under the management of Deacon Brown, and the continuation of local offices or warehouse facilities at Oklahoma City, Lindsay, Midland, Odessa, Corpus Christi, Houston, and Lafayette.

A new office will be opened in the Rocky Mountain area, with warehouses at Worland, while California operations will still be directed from Compton, Bakersfield, Long Beach, and Ventura.

We're Part of the

OIL INDUSTRY



THE spectacular development of Canadian oil wells is unprecedented in our history. But the full story of oil is yet to be told, since the future of the industry is indeed limitless.

Imperial Bank of Canada is playing its part in this great development. New industries in new territories can find unfamiliar conditions and the advice and help of a capable Bank Manager is freely offered.

Our special representative in the oil industry is Mr. A. S. de Rosenroll, manager of the main branch of the Imperial Bank in Calgary. His knowledge and experience are available to you as part of the Imperial Bank's facilities in the west. We maintain three branches in Calgary, five in Edmonton, and over fifty branches in the provinces of Alberta and Saskatchewan. Our Branch Managers are eager to serve your new industry's needs in every way.

IMPERIAL BANK OF CANADA

Worthington Pump and Machinery Names Commercial Vice President

Austin C. Ross

H. K. Beck

Harold K. Beck has been appointed commercial vice president, in addition to his present post as manager of the Washington office of Worthington Pump and Machinery Corporation.

Austin C. Ross, manager of the Buffalo works, has been elected a vice president of the company and will continue to serve as Buffalo works manager.

A 25-year veteran of Worthington, Beck received his B.S. degree in civil engineering from Tufts College in 1925 and then took the Worthington training course. Originally assigned to the export division, he was transferred to the Washington office the next year as a sales engineer. In 1933 he was appointed special representative for government contracts and in 1934 he was appointed district manager of the Washington office.

Ross joined Worthington in 1932 as assistant general purchasing agent, became assistant works manager of the Buffalo works in 1935 and works manager in 1940. He is a graduate of Toronto University, where he obtained his Bachelor of Applied Science in electrical engineering in 1915. From 1919 to 1931 he was associated with Rolls-Royce of America, Inc., in Springfield, Mass.

Hal Childers Joins Equipment Firm As Manager of Industrial Sales

Hal G. Childers has purchased an interest in Equipment, Inc., Houston, and will serve as industrial sales manager, C. E. (Chick) McCarthy, general manager of the firm, announced.

Hal G. Childers

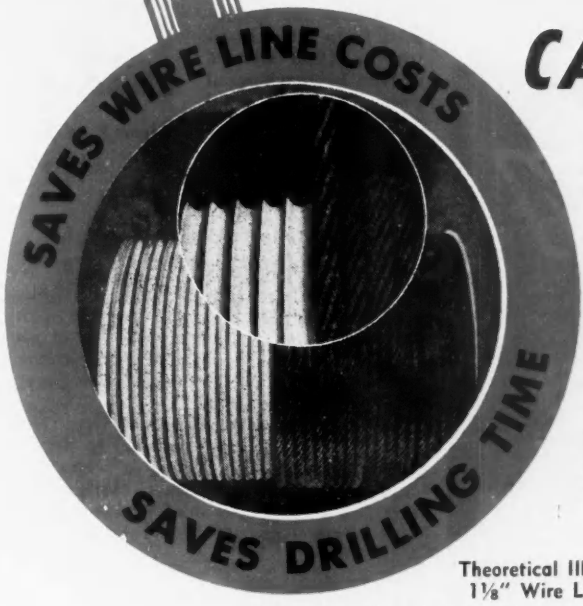
Childers, who was formerly in industrial and refinery sales with The Corbett Corporation, was graduated from Birmingham Southern College in 1939 and became connected with Tennessee Coal, Iron and Railroad Company, working in the plant until his transfer to the purchasing department. He joined Stockham Pipe Fitting Company in 1946 following service in the Army Air Forces.

Equipment, Inc., has added several new industrial lines, including Tube-Turns, Powell valves, Grinnell Malleable & Forge Steel Fittings and Merco-Nordstrom plug valves, as well as general lines of tools and hardware.

Look What A LEBUS

WIRE LINE GROOVING & SPOOLING SYSTEM

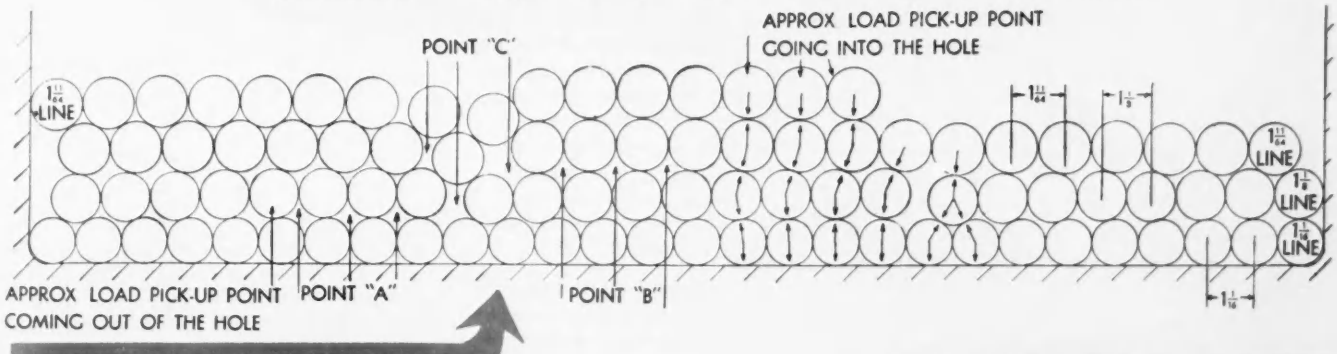
CAN DO FOR YOUR RIG!



The LeBus Wire Line Grooving and Spooling System has been engineered and developed to meet an urgent requirement to cut the costs and improve the performance of wire line. Pinching, Squeezing, Crowding and Mis-shaping of Wire Line is indicated by crooked arrows on *the Cross-Sectional drawing of the Flat or Plain drum below.* Flat Drum spooling is wasteful to Wire Line and hazardous to the Drilling Crew. These Wire Line Troubles are remedied when your Drum is grooved with LeBus Grooving and End Fillers *as shown below on the cross sectional drawing of a grooved drum.* Even a tapered or distorted line spools evenly and safely on a grooved drum. The loads line up as indicated by crossed arrows. The wraps "Pyramid" as shown with large triangle. This controlled contact and even loads mean longer life and safer drilling operation. The photograph and inset to the left is a drawworks drum with the LeBus Wire Line Grooving and Spooling System installed and with the first layer of line wrapped to the preferred pick-up point when coming out of the hole to change bits. It pays to look into LeBus Wire Line Grooving and Spooling—Many of the Largest Drilling Contractors have installed this system. Why? It has saved them money.

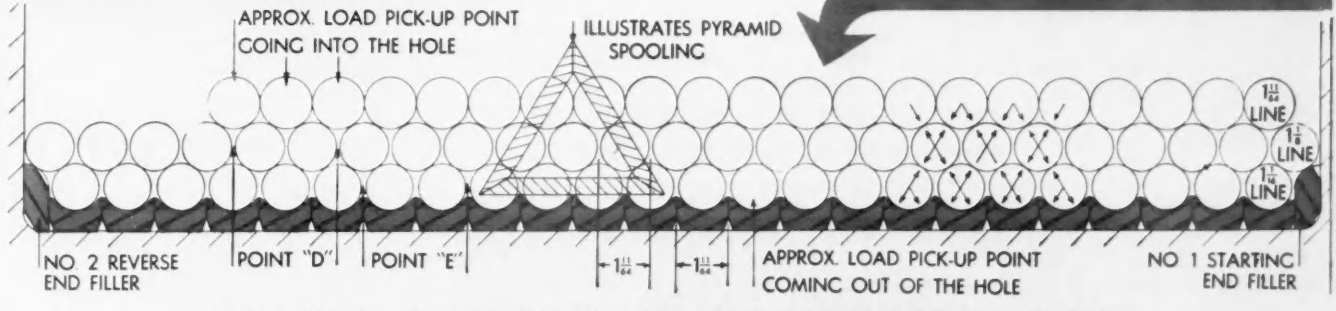
Theoretical Illustration of the Spooling of a Tapered or Stretched 1⅛" Wire Line. A.P.I. Tolerance 1⅛ + 3/64 or — 0 Diameter

This print also illustrates the comparable difference in the amount of line required on a plain drum and a grooved drum, when the pipe has been picked up to the required height for making connections.



PLAIN OR FLAT DRUM

DRUM WITH LEBUS GROOVING



LEBUS ROTARY TOOL WORKS, INC.

P. O. BOX 2352 • LONGVIEW, TEXAS • PHONE 1232

Canadian Representative: FRED S. DEWEL COMPANY, Casper, Wyoming

Executive and Sales Assignments Announced by Moore Corporation

O. H. Dittmer, Oklahoma district representative for Lee C. Moore Corporation, has been promoted to division sales manager covering Oklahoma, Kansas, the Illinois Basin and Rocky Mountain area. He is succeeded at Oklahoma City by Don Todd.

J. Y. Weatherly, A. B. Dunham and J. R. Roberts have been named district sales managers. Weatherly, who has been with Lee C. Moore since 1929, will be in charge of the Dallas district with C. M. Botefuhr as assistant. Botefuhr was transferred from the Dallas office.

Dunham will be in charge of the West Texas district with headquarters at Midland, Texas. J. E. Harrell is sales representative.

Roberts will have charge of the Gulf Coast district with headquarters in Houston. C. W. Hays is sales representative.

Mack Names Vice President

S. S. Stewart, formerly purchasing agent for the manufacturing division of Air Reduction Sales Company, has been named vice president in charge of purchasing for Mack Manufacturing Company.

Safe-all the Way
One of a series of typical Propane Truck Loading Racks
CHIKSAN Style 50x5 Counterbalance Swivel Joint
OKADEE L. P. G. Valve
WECO Wing Union
WECO Hi-Speed Thread Seal

Eliminate *all* the weak spots in your L. P. G. loading racks! Use CHIKSAN *Ball-Bearing* Swivel Joints, WECO Wing Unions, *Okadee* Valves and WECO *Hi-Speed* Thread Seal...and get *matched* safety all the way... plus dependable performance, low maintenance cost, easy handling and long life.

Wherever you handle liquids, vapors or gases through flexible lines, this engineered combination saves you time and money. CHIKSAN Engineers will gladly assist you in designing flexible lines for the safe handling of a wide range of products...in any length...any size...any pressure to 15,000 psi.

WRITE FOR CATALOG NO. 50

REPRESENTATIVES IN PRINCIPAL CITIES

SOLD BY LEADING SUPPLY STORES EVERYWHERE

CHIKSAN TRADE MARK REG.

CHIKSAN COMPANY

AND SUBSIDIARY COMPANIES

Chicago 3, Ill. BREA, CALIFORNIA Newark 2, N. J.

WELL EQUIPMENT MFG. CORP. HOUSTON 1, TEXAS

CHIKSAN EXPORT CO. BREA, CALIFORNIA NEWARK 2, N. J.

BALL-BEARING SWIVEL JOINTS FOR ALL PURPOSES

Dresser Manufacturing Appoints Southeastern Area Representative

Dresser Manufacturing Division has appointed Henry F. Peebles as Southeastern representative, to work with customers in Florida, Georgia, North Carolina, South Carolina, Kentucky, Mississippi, Virginia, Alabama, Tennessee, and parts of Indiana.

Henry F. Peebles

Peebles was graduated from Rice Institute in 1948 with a degree in mechanical engineering, and worked for a while with Magnolia Petroleum Company before joining Dresser about two years ago.

Kerotest Company Acquires Right To Manufacture New Plug Valve

Manufacturing rights have been acquired by Kerotest Manufacturing Company, Pittsburgh, to produce a new type of plug valve which has been under development and production by General Valve Service Company, Long Beach, Calif.

The non-lubricated plug valve is designed for operation at normal to sub-zero temperatures and provides a vapor-tight shut-off for gaseous and volatile liquid service. It will be marketed under the tradename Kerotest General Twin Seal Valve.

Roebling's Sons Company Appoints Spofford as Director of Purchases

Robert K. Spofford has been named director of purchases for John A. Roebling's Sons Company, Trenton, N. J. He will be in charge of the procurement of materials used in the manufacture of wire rope, electrical wire and cable, woven wire fabrics, cold-rolled steel and related products.

Robert K. Spofford

For the past seven years, Spofford was with The Okonite Company, and for five years as purchasing agent.

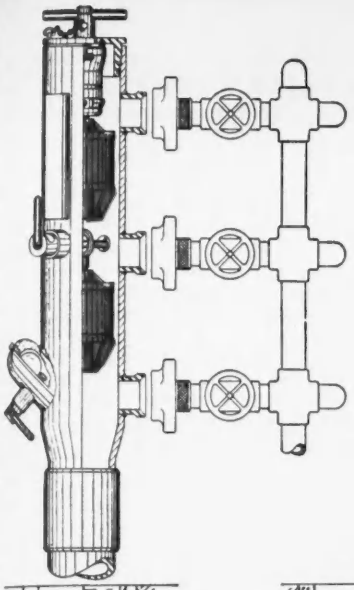
Hercules Tool Company Announces Additional Field Representatives

M. L. Creed has joined Hercules Tool Company of Tulsa and will represent the firm in East Texas, North Louisiana, Mississippi and Arkansas, with headquarters in Kilgore, Texas.

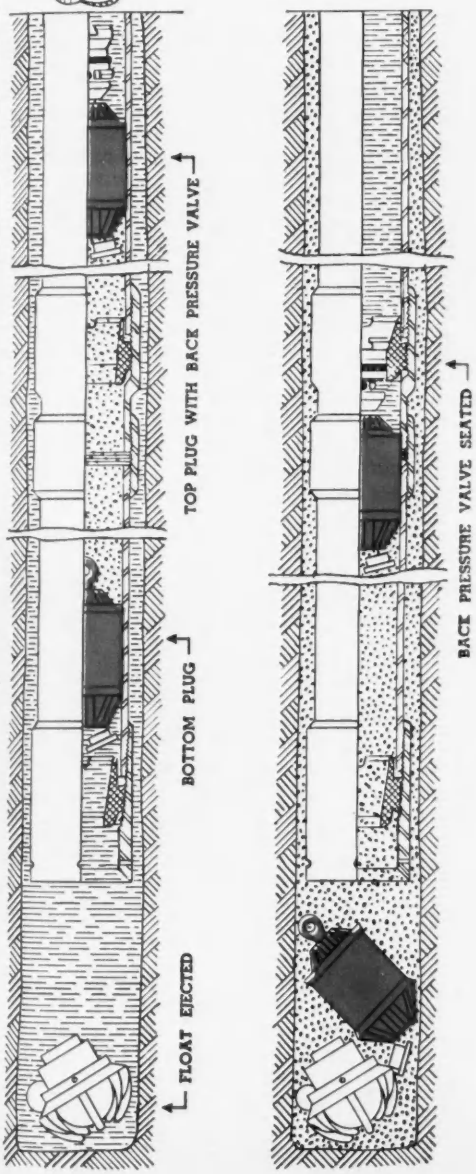
Other Hercules appointments include those of F. R. (Tod) White, Midland, Texas, as representative for West Texas, New Mexico and Arizona, and Harold R. Jarvis, Mount Carmel, Ill., in Illinois, Indiana, Kentucky and Michigan.

Producers Supply Names Manager

P. M. (Pete) Kovack has moved to Wichita Falls, Texas, as store manager for The Producers Supply & Tool Company.



There's *only one* way to be sure of a MASTER CEMENTING job . . . that's with the RECTOR "FULBORE" CEMENTING METHOD



A Master Cementing job puts the specific volume of uncontaminated cement behind the casing . . . sets up a secure, leak-proof bond between casing and open hole . . . reduces amount of cement left in casing and bottom of hole to a minimum. It is that can be done efficiently and quickly, without trouble and practically no downtime from beginning to end of operations.

Rector Fulbore Cementing is the *only* method that can give you this kind of a job.

1. **The two plug method separates cement column from mud fluid . . . delivers uncontaminated cement at casing shoe.**
2. **Uniform body of cement at shoe and shoe joint minimizes hazard of channelling.**
3. **Greater casing discharge capacity at lower pressure is obtained by ejecting float assembly from shoe before cementing.**
4. **Positive back pressure valve prevents back flow of cement when seated in stall collar.**
5. **Plug retainer type cement head provides closed circuit that prevents air entrainment in cement column. Trip ball, two plugs and back pressure valve released from head with practically no downtime.**
6. **Cement placement in annulus back of casing accomplished in minimum time.**

Ask your Rector Representative or Supply Man for facts and details about a Master Cementing Job with THE RECTOR FULBORE CEMENTING METHOD, or write for bulletins.

RECTOR WELL EQUIPMENT CO., INC.

FORT WORTH, TEXAS

Ft. Worth Plant, 1100 N. Commerce St. Houston Plant, 2215 Commerce St.

REPRESENTATIVES IN ALL ACTIVE FIELDS.

RECTOR FULBORE CEMENTING METHOD

ASK YOUR SUPPLY STORE FOR RECTOR "FULBORE" CEMENTING EQUIPMENT

KERN
DIRECTIONAL DRILLING CORP.

- SIDETRACKING
- STRAIGHTENING
- CONTROL DRILLING
- CONSULTING

HOUSTON: P. O. Box 8055
Phone: KEystone 6123

ABILENE: G & L Tool Co.
Phone: 5555

BARRET

SPECIALIZING IN MAGNETIC SURVEYS

Contracts accepted for domestic and foreign projects, using the most improved instrumental and interpretative technique.

William M. Barret, Inc.
Consulting Geophysicists
GIDDENS-LANE BUILDING
SHREVEPORT, LOUISIANA

Red Top (Hydrostatic) BAILER
A QUICK, POSITIVE LOAD REGARDLESS OF FLUID LEVEL.
Ideal also for fishing small objects—widely used for drilling in (completing) wells, and for drilling cement or plastic plug overages.

REYNOLDS SPECIALTY COMPANY, INC.
SHREVEPORT, LOUISIANA, U. S. A.
Office: 804 Erie St., Phone 7-7511
If no answer call 2-2023, 7-4966, or 2-5842
Factory: 2134 Greenwood Rd., Phone 2-2023
COMPLETE INSURANCE COVERAGE

Louisiana:
JENA, Germany Machine Co.
RODESSA, Republic Supply Co.
SERVICE, phone Jack Willhoit, 4662 Lafayette, 7-7511 Shreveport, Sam Hattaway, Ph. 6263, 6731 Houma.

Arkansas:
EL DORADO, Cox Supply Co.

Oklahoma Service:
OKLAHOMA CITY, Dawson Service Co., Phone 54-7577

Texas:
CORPUS CHRISTI, A. S. Baylor, Phone 2-2461.
BORGER, Nichols Tool Company, phone 350.
KILGORE, Spain Brothers, phone 2981.
SERVICE, phone 3, Turnertown; 2981, Kilgore;
TALCO, Talco Lumber Co.
SEMINOLE, A. C. Simmons, phone 404-J.

EQUIPMENT and SERVICE SUPPLIERS' NOTES

Two Accept Supervisory Positions With Southern Geophysical Company

G. D. Larson

Ralph C. Cole

G. D. Larson and Ralph C. Cole have joined Southern Geophysical Company of Fort Worth in supervisory positions, Dr. Sidon Harris, president, announced.

Larson has been with Stanolind Oil and Gas Company for the past nine years and his experience in seismograph surveying has extended over the Gulf Coast, Mid-Continent and Rocky Mountain oil provinces. Larson has a master of science degree with a major in geology from the University of Iowa.

Cole has been in geophysical work since 1934 when he was graduated with a B.S. degree in mechanical engineering from the Missouri School of Mines in Rolla. During the past 16 years he was with Western Geophysical Company, Stanolind, and Carr Geophysical Company before he joined Southern. Cole's seismograph surveys have taken him to Alabama, Mississippi, Louisiana, Arkansas, East Texas and the Gulf Coast.

Industrial Engine Dealers Attend Conference at Chrysler Corporation

Fifty-one dealers and key men in their organizations attended a four-day conference held by the Industrial Engine Division, Chrysler Corporation, in Detroit. Meetings were held in the auditorium of the administration building of the Chrysler Jefferson plant.

The program largely was given over to a "clinic," in which every possible phase of selling and servicing industrial engines of Chrysler manufacture was discussed. The visiting dealers were afforded an opportunity to ask questions freely. Thus they had the benefit not only of the company's thinking but also of an interchange of ideas among themselves. There were two daily sessions Monday through Thursday, with J. C. Hammelef, manager of the Industrial Engine division, presiding, assisted by R. H. Westrick, service manager, C. H. Williams, project engineer, and all members of the field force. Robert T. Keller, president of the division, headed the group of hosts.

In the course of the conference, the company spokesmen told of plans for still further expanding the business of this rapidly-growing branch of Chrysler Corporation activities in a field where it has gained wide acceptance. Service matters were extensively discussed and engine adaptation occupied the greater part of two days.

Rockwell Vice President Resigns To Form New Company in Chicago

William A. Marsteller has resigned, effective January 1, as vice president of the Rockwell Manufacturing Company of Pittsburgh and as vice president and director of Edward Valves, Inc., East Chicago, Ind., to establish The Marsteller Company, consultant in marketing and advertising. The new firm will be located at 612 North Michigan Avenue, Chicago, after the first of the year.

Marsteller has been responsible for advertising, market research and sales promotion for the Rockwell Manufacturing Company and its 14 divisions. Recently in an executive advisory capacity with Edward Valves, he was formerly in charge of sales, advertising and employe relations.

International Cementers Elects Veteran Oil Man Vice President

International Cementers, Inc., Long Beach, Calif., has elected Frank D. Smith as a vice president of the corporation.

Frank D. Smith

Smith's oil field experience dates back to 1912. He became affiliated with ICI in September, 1943, as a sales representative in the Los Angeles Basin. In January, 1945, he was advanced to California division manager, and in June, 1949, became assistant general manager of the company.

EQUIPMENT and SERVICE SUPPLIERS' NOTES

Page Oil Tools Appoints Gunn as Vice President and Sales Manager

John R. Gunn has been made vice president and sales manager, and a member of the board of directors of Page Oil Tools, Inc., Long Beach, Calif. Gunn was formerly general superintendent of the Machinery and Outfitting division for Western Pipe & Steel's shipbuilding program, and before joining Page he was sales representative for Alexander H. Kerr & Company, Inc., Huntington, W. V.

John R. Gunn

Page tools are marketed in the Mid-Continent by the D+B division, Emsco Derrick & Equipment Company and The Continental Supply Company.

Chief Engineer, Abilene Manager Are Named by Empire Machinery

The Empire Machinery Company, Ltd., has appointed E. A. Studer as its chief engineer, with headquarters in Odessa, Texas. He will supervise all engineering work in connection with the shop and machinery sales.

The company also announced the transfer of W. K. (Kenny) Richey from Odessa to Abilene, Texas, as Abilene district manager in charge of Empire sales and service.

A graduate mechanical engineer, Studer was formerly with Dynamatic Corporation and has done both plant and field work in the Permian Basin.

Spencer-Safford Loadcraft Names Seed as Executive Vice President

William H. Seed, formerly controller of Cardwell Manufacturing Company, Inc., has been named executive vice president of Spencer-Safford Loadcraft, Inc., manufacturer of heavy industrial trailers.

A graduate of the U. S. Naval Academy in mechanical engineering, Seed joined Cardwell in 1945, after active Naval duty.

McPeake Is Named Sales Manager For Aldrich Pumps at Allentown

R. H. McPeake has been appointed sales manager of The Aldrich Pump Company, Allentown, Penn. McPeake, a graduate of the U. S. Naval Academy, had eight years' oil field experience with Standard Oil Company (N. J.) in both the Mid-Continent and Peruvian fields. In 1938, he left Standard to join The Oil Well Supply Company, where he became export sales manager. In 1942, McPeake joined the U.S. Navy and served for three years, after which he became a partner in an industrial engineering and importing firm in Buenos Aires, representing American manufacturers.

R. H. McPeake

Guaranteed to save
TIME, WORK AND CASH

"The tougher the job, the tougher the tools have gotta be—for me that's RIDGIDs."

If this Housing ever Breaks or Distorts we will replace it Free
THE RIDGE TOOL CO. ELYRIA, O.
TRADE RIDGID MARK PAT. 1727623
14

RIDGID's guarantee means no pipe wrench housing expense—at all, ever

● Workers everywhere like the work-saver features that make RIDGID the world's favorite. Housing is guaranteed against breakage or distortion. Adjusting nut spins easily in all sizes 6" to 60." Handy pipe scale on hookjaw. Instant-action non-slip, non-lock jaws. Powerful comfort-grip I-beam handle with flared end that won't let your hand slip off. RIDGIDs save your time and money. Buy them at your Supply House.

RIDGID
WORK-SAVER PIPE TOOLS
THE RIDGE TOOL CO. • ELYRIA, OHIO

Sure in all weather

Santa Fe freight service

Your freight moves by the clock—not by the weather—when you ship via Santa Fe.

Modern all-weather dispatching methods speed freight through terminals and a powerful fleet of diesel locomotives keep traffic rolling along the line to give dependable on-time arrival at destination.

Even Santa Fe's main freight routes are favored by nature for all-weather operations as these routes are without extreme changes in temperature or climate.

It pays to ship Santa Fe—*the dependable all-weather-way.* For information call your nearest Santa Fe freight representative.

F. H. Rockwell, *General Freight Traffic Mgr.*
Santa Fe System Lines, Chicago 4, Illinois

Santa Fe—*all the way*

Santa Fe

EQUIPMENT and SERVICE SUPPLIERS' NOTES

Westcott & Greis Division Elects Natural Gas Man as President

J. H. Satterwhite has been elected president of Westcott & Greis, Inc., division of American Meter Company, with headquarters in Tulsa.

J. H. Satterwhite

A graduate of Virginia Polytechnic Institute, Satterwhite entered the natural gas field in 1911. In the succeeding years he assisted in the original tests on orifice meters and operated as a meter tester throughout western Pennsylvania and eastern Ohio. In 1917 he became associated with Henry Greis, then sole owner of Westcott & Greis which became a division of American Meter Company in 1933.

Bethlehem Supply Company Makes Several Personnel Assignments

Bethlehem Supply Company has transferred C. E. Barnard, formerly chief clerk of the Tulsa sales office, to the Dallas sales office as office manager. He has been replaced at Tulsa by H. E. Arnold, formerly chief clerk for the division managers.

P. W. Behrents, formerly in the Engineering Sales department of the Tulsa general office, has been promoted and transferred to Odessa, Texas, as engineering representative.

I. H. Correll, formerly store manager at Craig, Colo., has been transferred to Grayville, Ill., as field representative. V. H. Prange, who has been field representative at Houston, has been transferred to McAllen, Texas, and promoted to store manager.

D. G. Shank has moved from Lake Charles, La., to Harvey, La., and promoted to field representative.

B. M. Queen, field representative at Kermit, Texas, has moved to Artesia, N. M., in the same capacity. J. W. Jillson was recently employed as field representative, and will work out of the Odessa, Texas, store. L. F. Ritchie, formerly field representative at Odessa, has been promoted to special representative. D. R. Nicholson has been promoted to manager of the Pump Shop at the Odessa store.

Totco Expands Los Angeles Plant For Increased Productive Capacity

Technical Oil Tool Corporation, Ltd., has opened a new section of several thousand square feet of floor space at its Los Angeles manufacturing plant. New machine tools including Swiss automatics, turret lathes, and gear burnishers have been installed to increase the productive capacity of the plant.

Totco plans to put new instruments on the market and is doing certain development work for the government.

Oil Well Research Firm Moves

Oilwell Research, Inc., has moved its Long Beach, Calif., headquarters to 1539 West 16th Street, Long Beach 13.

New Books, Maps and Movies

Safe Practices Manual

A new pocket-size, 60-page manual entitled, "Safe Practices Manual for Oil Well Drilling Operations" has been compiled by the Texas Bureau of Labor Statistics. Recommendations contained in the manual represent the cumulative experience and careful study over a long period by thousands of men in the drilling industry. It contains a detailed index.

R. B. Latting, Safety Supervisor, Texas Bureau of Labor Statistics, Austin.

Story of California Oil

"Black Bonanza," by Frank J. Taylor and Earl M. Welty, is a historical narrative of oil in the West, as revealed in a study of the Union Oil Company of California, which the authors selected as a fair cross-section of the petroleum industry as a whole.

Among the pioneers of Pennsylvania's petroleum boom in the Sixties was Lyman Stewart, who later helped found California's oil industry, and who lived to see petroleum become the lifeblood of the modern world.

"Black Bonanza" starts two decades before the first well was drilled in Pennsylvania and carries through to the present. It upsets a number of long accepted ideas and stories of the petroleum industry, but it is fully documented in every particular. It is illustrated with 186 photographs.

McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 18, $4.

Valve Manual

Of interest to specifiers, buyers and users of valves, is a new "Manual of Equivalent Valves," which was compiled by H. Gordon Hawes, valve engineer. The manual contains 175 pages of data on equivalent valves, listing the valves of 18 leading manufacturers. All information has been checked by each of the manufacturers. The listing shows which valves are equivalent, and the design and variations, and is intended as a ready reference for engineers, purchasing agents and engineering personnel who develop specifications or make purchases of valves.

Basically the manual is a guide to the difference between the valves of these 18 manufacturers for a given type, material, and pressure rating. In case a certain valve is in short supply or unobtainable, the listing shows which other valves are equivalent. Also when purchasing on an "or equal" basis, one may determine which valves are equal or equivalent.

Hooper Publishing Company, 545 Sansome Street, San Francisco 11, $15.

Steel Casting

Importance of the steel casting industry as a significant contributor to industrial progress and economic welfare of the nation through the last century is emphasized in "A History of Steel Casting." The book was prepared under the direction of William H. Worrilow, president of Lebanon Steel Foundry, Lebanon, Penn., edited by Arthur D. Graeff, and published under the auspices of Division No. 1, Steel Founders' Society of America.

The 168-page volume includes a general history of the ferrous foundry industry, and reports on the origin of steel castings in Germany, Switzerland, England and the U. S. It contains a detailed primer of steel casting production.

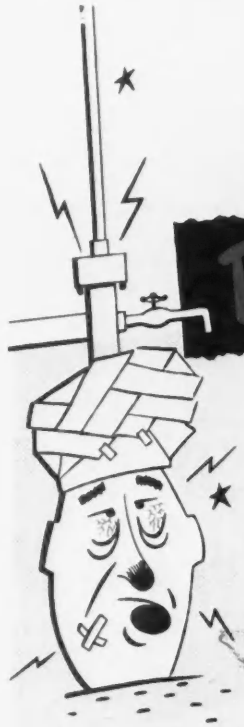
Fully illustrated, the book has almost 50 photographs of plants, personalities and processes; scratchboard drawings and sketches, many of historic and timely importance. A detailed national map shows the geographical divisions of the Steel Founders' Society, together with a historical review, sections devoted to moirs and reminiscence of early leaders, and an index.

William H. Worrilow, president, Lebanon Steel Foundry, Lebanon, Penn., $2.50.

Capillary Flow

A 16 mm. color sound film, "Microscopic Studies of Capillary Flow," shows the technique used for producing and mounting sand-filled capillaries on microscopic slides and a microphotographic motion picture study of the flow of air, oil and water through the pore structure.

Audio Visual Aids Library, The Pennsylvania State College, State College, Penn., service charge $1.25.

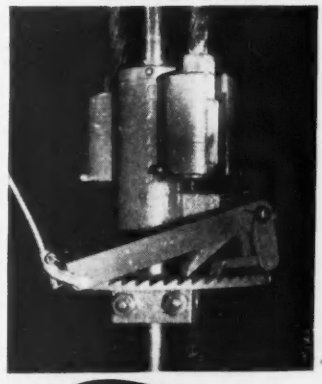


A SURE CURE for PARAFFINITIS*

There is no need to put up with this malady . . . no need to give your wells frequent and costly treatments of steaming out or pulling the rods to remove paraffin and maintain production.

Huber Paraffin Scrapers are a permanent cure for paraffin accumulation. Attached to the sucker rods, they wipe the tubing walls clean of paraffin. The scraper blades are shrink-fitted to the rods which are rotated by the Huber Rotating Rod Hanger. Wiping action takes place as the string is rotated and reciprocated.

DOUBLE BENEFIT ROTATION



The combined rotating and reciprocating motion wipes paraffin from the tubing in particles so small they go out in solution . . . can not clog tubing, scrapers, or flow lines. Rod rotation prolongs coupling life by equally distributing wear . . . prolongs pump life and efficiency by equalizing wear on working barrel. Get this added benefit while eliminating paraffin accumulation by installing Huber Scrapers and Huber Rotating Rod Hangers.

Cure your wells of paraffin accumulation . . . install Huber Paraffin Scrapers and Rotating Rod Hanger, NOW!

* Congestion caused by the accumulation of paraffin in pumping wells.

For further information see your local supply store, or write

J. M. HUBER CORPORATION,
Box 831 . . . . . Borger, Texas

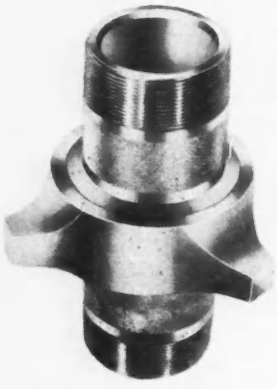
HUBER

PARAFFIN SCRAPERS

SCRAPE AS THEY ROTATE AS THEY RECIPROCATE

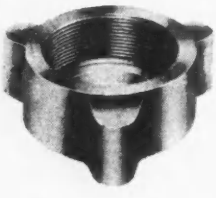
DRILLING EQUIPMENT MFG. CO.
DEMCO
OKLAHOMA CITY, OKLA. U.S.A.

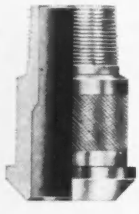
HYDRAULIC HOSE ADAPTERS



Under the most rigid tests DEMCO adapters have proved themselves most efficient, economical, foolproof and safe.
Designed to take the stress of high pressure at any depth and eliminate all possible resistance to flow. Made of high quality non-crystallizing steel. Precision machined to A.P.I. specifications and knurled for better grip. Outer surfaces electroplated to retard corrosion.

Designed for 3000 lbs. working pressure, 6000 lbs. test.

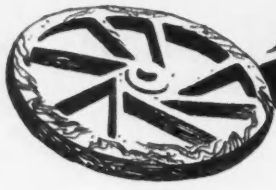




These Adapters and Couplings meet the requirements of all major swivel manufacturers, and will make up any combination or hook-up in the three or four-inch A.P.I. series for both swivel and standpipe.

Sold through your supply store.

DRILLING EQUIPMENT MFG. CO.
OKLAHOMA CITY, OKLAHOMA
PHONE 6-1342 845 S.E. 29th St. Box 4272



SQUEAKS from the BULLWHEEL

Aged in the Wood

"Look, dear, how picturesque! The Smiths are bringing in an old Yule log."
"Yule log, my eye! That's Smith."

Addendum

In a very interesting advertisement last month, John Eastman of Eastman Oil Well Survey Company said:
"Some one once said, 'The really big man is a humble man.'"
Paul Hubbard of Gulf got a clipping of the ad, with the quotation circled, and this comment: "Don't worry, Paul—sometime a Gulf, Shell, Stanolind or Texas man will make it!"

Just Like Home

Two travelers arrived at the hotel and were shown a rather dingy room.
"What," asked one, "does this pigsty cost?"
Promptly the proprietor replied:
"For one pig, two dollars; for two pigs, three dollars."

Sound Off

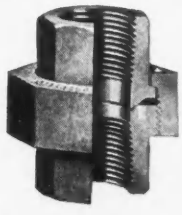
Two veterans were boasting about their old outfits.
"Why, our company was so well drilled," said one, "that when we presented arms, all you could hear was slap, slap, click."

"I don't care what kind of luck you're having! Get back to work!"

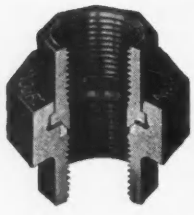
"Pretty fair," said the other, "but when our company presented arms you could hear slap, slap, click, jingle."
"Jingle?" said the other. "What did that?"
Came the reply, "Oh, just our medals."

Jefferson Malleable Unions

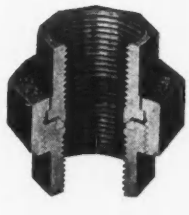
STYLE "B"—3-Part Ground Joint pipe line flange union greatly facilitates the laying of pipe and especially where pipe is out of alignment. Certified Air Furnace iron. Sizes ½" thru 10".



STYLE "A"—Ground Joint union and union fittings. Complete line straight and reducing. Sizes ⅛" thru 2½"—3000 lb. test; 3" and 4"—2000 lb. test. Made of Certified Air Furnace iron.



ENDURO—300 lb. S.W.P.—600 lb. C.W.P. unions. Sizes ⅛" thru 3".



EXCEL—250 lb. S.W.P.—500 lb. C.W.P. unions. Also a complete line of unions, ells and union tees with union on the run. Made of Certified Air Furnace iron. Sizes ¼" thru 3".

Obtainable through your jobber

Jefferson Union Company, Inc.

691 West 26th St.,
New York 1, New York

71 Gooding St., Lockport, New York
31 Fletcher Ave., Lexington 73, Mass.

McCULLOUGH SERVICES:

A ELECTRIC WIRE LINE SERVICES

1. PERFORATING—Deepest penetrating burrless bullet and jet.
2. BRIDGING PLUGS—Drillable, expandable. McCullough and Baker.
3. MAGNA-TECTOR*—Locates stuck point of pipe, accurately, fast!
4. JET CASING CUTTERS*—World's fastest casing, tubing, drill pipe cutter!
5. JET BACK-OFF TOOL* and STRING SHOT—World's fastest way to recover stuck pipe!
6. JET BOTTOM HOLE CUTTERS*—Fragmentizes lost or stuck fish!
7. ELECTRONIC WEIGHT INDICATOR*—Supersensitive, small, light!
8. SONIC COLLAR LOCATOR*—Locates collars, liner top, well bottom, etc.
9. MAGNETIC FISHING TOOL*—Surface indicates location and recovery of fish.

B ROTARY SERVICES

1. DOUBLE ACTING ROTARY JARS* and BUMPER SUBS—Reduces number of fishing jobs!
2. SAFETY JOINTS—Releases quickly in emergencies!
3. EXTERNAL DRILL PIPE CUTTERS—For all outside pipe cutting.
4. MECHANICAL LONG KNIFE INTERNAL CASING CUTTERS—All sizes pipe, tubing.
5. THIN WALL EXTERNAL CASING CUTTERS*—For outside cutting in small clearances!
6. ROTARY RELEASING OVERSHOTS—Completely encircles fish.
7. ROTARY RELEASING SPEARS—Engages or disengages at will.
8. GUN TESTER—Water shut-off, perforating, testing in one run.
9. JUNK BASKET—Crushable finger type. 5 minutes on bottom.

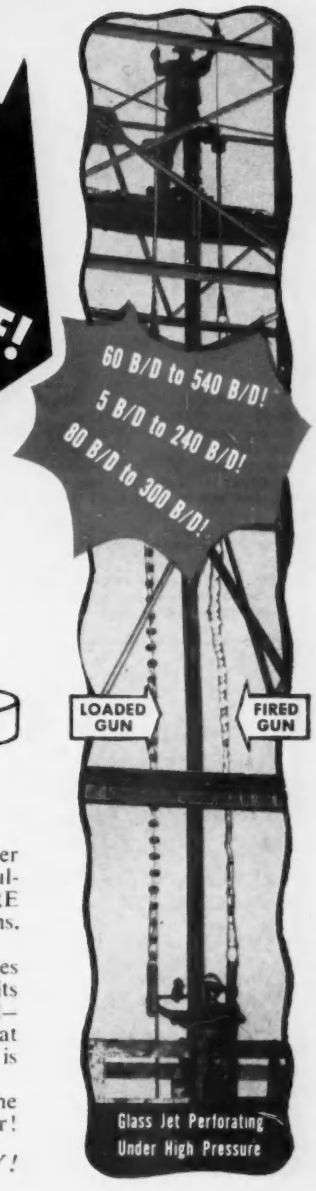
*Exclusive McCullough Services

PETROLEUM EQUIPMENT SUPPLIERS ASSOCIATION MEMBER

McCULLOUGH® GLASS JET PERFORATORS

Mean MORE OIL in the tank, even after all other methods fail!

PROOF!



MORE *Oil in the TANK means MONEY in the BANK...*

...and that's what you're after!

When you want cleaner, deeper, straighter holes, even after all other methods had failed to get results, there is only one choice—the new McCullough Glass Jet Perforator. Your reward—MORE OIL in the tank, MORE MONEY in the bank! No carrots or slugs, no splitting or sticking guns, trouble-free jet perforating for the FIRST time!

No matter how you look at it the McCullough Glass Jet Perforator makes sense. The emphasis is on the Glass Jet and not on the carrier. This permits the maximum safe charge of explosives where MORE POWER is needed—in small pipe in deep wells where several casing strings exist. The special heat treated glass units disentegrate completely. The retrievable strip carrier is pulled from the well.

Whatever your perforating problems—you're after MORE OIL in the tank. GET what you're after with the McCullough Glass Jet Perforator!

AVAILABLE NOW—See Your McCullough Service Man TODAY!

McCULLOUGH Tool Company

5820 South Alameda Street, Los Angeles 58, Calif. • 405 McCarty Street, (P.O. Box 2575) Houston, Texas
Export Office: Los Angeles, California

TEXAS: Snyder, Alice, Houston, Cisco, Corpus Christi, McAllen, Odessa, San Angelo, Tyler, Victoria, Wichita Falls. **OKLAHOMA:** Oklahoma City, Guyman, Healdton. **MISSISSIPPI:** Laurel. **NEW MEXICO:** Hobbs. **KANSAS:** Great Bend. **CALIFORNIA:** Los Angeles, Avenal, Bakersfield, Ventura. **LOUISIANA:** Houma, Lake Charles, New Iberia, Shreveport. **WYOMING:** Casper. **CANADA:** Edmonton. **VENEZUELA**—United Oilwell Service Co., S.A.: Caracas, Anaco, Maracaibo.

Mid-Continent NEWS and HUMOR?

IT WOULD BOWL YOU OVER. At least, we *think* you'd be surprised at some of the names on our mailing list. Reads like a Who's Who of the oil business. That's downright amazing when you consider that the MID-CONTINENT NEWS is about as unpretentious as a magazine can be, but maybe it is right down your alley!

WE JUST COOK UP some company news, toss in a lot of photographs, spice the whole thing with an assortment of jokes, cartoons and teasecake—and out comes a magazine that people seem to like. Don't ask us why. We're still trying to figure it out.

THE NEWS was designed originally for employees only. But quicker than you can say "World's Largest Independent Oilfield Supply Company," our mailing list split its seams. Customers, friends, oil men from all over the country asked for the NEWS. The list is still growing, and there's room on it for your name. Just mail a request on your company letter head to the Advertising Department of

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SQUEAKS FROM THE BULLWHEEL

Up a Western Creek

A visiting Texan was enjoying the wonders of California as pointed out by a native.

"What beautiful grapefruit," he said as they passed a grove of citrus trees.

"Grapefruit! Why those are lemons and small ones at that, because of the comparatively bad season," explained the Californian.

"And what are those enormous blossoms?" queried the Texan as they moved along.

"Just a patch of dandelions," answered the guide.

Presently they reached the Sacramento River. "Ah," said the longhorn, "someone's radiator is leaking."

Creation

The chap who split the atom
Rates no halo or hozannah
Like the soda fountain phizzisist
Who split the first banana.

Age of Innocence

"Lady, you'll have to pay full fare for that boy. He must be over 12."

"How can he be over 12 when I've been married only ten years?"

"Listen, lady, I collect fares—not confessions."

Testimonial

Harry was tired, listless, run down, couldn't sleep, had lost his pep and was the victim of sour stomach—and worse than that, realized that he was middle-aged. Finally won over by the advertisements for a widely-publicized patent medicine, he bought a bottle and drank it down. That evening, he went to bed and fell asleep—and slept, and slept, and slept. The next morning his wife went in to wake him up.

He stretched and yawned and scratched his head, then opened one eye and said: "All right, Ma, I'll get up—but I ain't going to school!"

Suffrage, Yet!

The lawyer was arguing against allowing women to serve on juries.

"How," he asked, "could a jury of six young men and six young women be locked up in a jury room for 12 hours and come out and say, 'Not Guilty'?"

Undercover Job

A welder and a tractor driver on a pipe line job were having a lively argument over the question of whether welders or tractor drivers were better qualified to run a spread. After some minutes of give and take on both sides, the tractor driver put an end to it by announcing:

"Hell, when all the work is going on, you welders have your heads covered up with those hoods, so how can you know anything about the rest of the work?"

Only One Way Out

The tired business man arrived home. The cook had left that morning without notice . . . his daughter had eloped . . . junior had smashed the car . . . the market had been depressed all day causing him great financial loss, and to climax the evil day he found a farewell note from his wife. He knew a shot would end it all . . . so he opened a bottle and took one.

The Final Word

"You can't marry her without permission," said the young lady's father.

"Why not?" asked the young suitor.

"Because she's a minor."

The young man looked startled for a moment, then asked: "You mean I have to ask John L. Lewis?"

Steel Problems?

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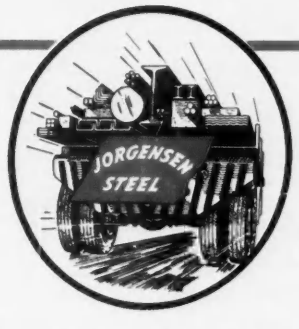

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SQUEAKS FROM THE BULLWHEEL

You Tell Me

Jane: "Why is it that you have so many boy friends?"

Alice: "I give up."

Humanity in the Insect World

Jackson and his wife were doing a little fly hunting about the house.

"How many have you caught?" she asked after a while.

"Six," replied her husband. "Three males and three females."

"How absurd!" his wife sniffed. "How could you tell if they were males or females?"

"Easy, my dear," he retorted. "Three were on the sugar and three were on the mirror."

Grid Grilling

Now that the season is almost over, it seems safe to pass on a few observations on that great American hysteria, football. We heard the other day about a college halfback who has been voted to a place on most of the All-American selections, and is now debating the possibility of playing pro ball next season. He likes the game and would like to go on playing after he leaves college, but he hates to think of the cut in salary.

There is also a story going around about the dowager who chanced upon a strange college campus and asked a husky young student, "Young man, can you tell me the name of this school?"

"Sorry, Ma'am," he replied. "I just play football here."

Natural Mistake

I had sworn to be a bachelor;
She had sworn to be a bride.
But I guess you know the answer—
She had nature on her side.

"Speak up, man! You're in the right office—I'm in charge of the company's Arabian business."

Not By a Long Shot

A gentleman, on being informed that he was the father of triplets, rushed to the hospital and burst joyously into his wife's room. The nurse was not pleased to see him.

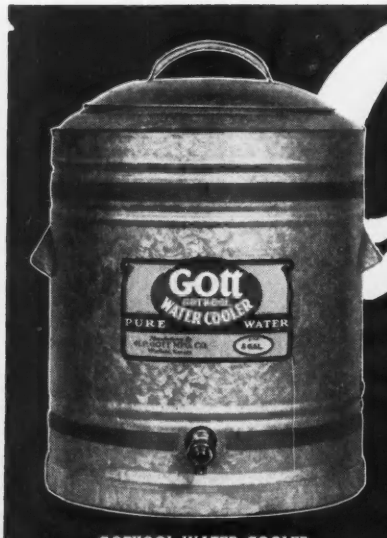
"You can't come in here covered with germs," she said. "You're not sterile."

"You're telling me I'm not!" replied the husband.

Satisfaction Not Guaranteed

Don't think that every sad eyed woman has loved and lost; she may have got him.

But, on the other hand, that just goes to prove that women are never satisfied. Did you ever notice that women are always trying to take off weight, put on weight, or trying to rearrange it?



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Producing Formation

ROOSEVELT

BOUGH

Roswell

BITTER LAKE

CHAVES

COMMANCHE

CHISHOLM

BAGLEY

HIGHTOWER

CAPROCK

NORTHWESTERN SHELF ARE

LEA

DEN

HIGH LONESOME

S. HIGH LONESOME

RED LAKE

DOUGHERTY

FORREST

ANDERSON

SQUARE LAKE

ROBINSON

N. MALJAMAR

W. ROBERTS

ROBERTS

Lovington

LOVINGTON

W. LOVINGTON

LOGAN DRAW

EMPIRE

CAVE

GRAYBURG

JACKSON

MALJAMAR

BAISH

VACUUM

LOCO HILLS

PREMIER

PEARSALL

CORBIN

ATOKA

DAYTON

ARTESIA

NICHOLS

LEO

N. SHUGART

YOUNG

S. MALJAMAR

PALMILLO

TURKEY TRACK

CULWIN

SHUGART

WATKINS

BOWERS

BENSON

W. LUSK

LUSK

E. LUSK

TONTO

MCMILLIAN

BURTON

RUSSELL

GETTY

P.C.A.

HALE

SALT LAKE

N. LYNCH

LEA

EUNICE MONUMENT

NIPPER-MCKINNEY

SCANLON

BARBER

HALFWAY

LYNCH

WEIR

EDDY

FENTON

WILSON

W. WILSON

EUNICE

Carlsbad

ARROWHEAD

SAN SIMON

S. EUNICE

BLACK RIVER

COOPER JAL

NEW MEXICO

Map of WEST TEXAS—SOUTHEAST N

MATADOR UPLIFT

BAILEY

LAMB

HALE

ANTON-IRISH

CRAVENS

YELLOWHOUSE

Morton

COCHRAN

HOCKLEY

LEVELLAND

Levelland

SMYER

Lubbock

LUBBOC

SAWYER

CROSS ROADS

ROPES

SLAUGHTER

RHODES

LANDON

ALEX

NEW MEXICO

TEXAS

NORTH BASIN PLATFORM

YOAKUM

Plains

COBB

BRAHANEY

OWNBY

WAPLES PLATTER

WEST

TERRY

MOUND LAKE

Brownfield

LYNN

WELLMAN

DENTON

WASSON

CORRIGAN

JONES RANCH

ADAIR

GARRETT

N. RUSSELL

KNOWLES

BROWN

RUSSELL

CEDAR LAKE

WELCH

DAWSON

N. HOMANN

W. SEMINOLE

SEMINOLE

HOMANN

N. RILEY

Seminole

Lamesa

HOBBS

E. HOBBS

RILEY

GAINES

SPRABER

DOSS

JENKINS

ROBERTSON

KIRK

HOUSE

CASS

SKAGGS

WARREN

HARDY

FLANAGAN

N. DRINKARD

ELLIOTT

UNION

BLINEBRY

BRUNSON

FULLERTON

MEANS

PENROSE-SKELLY

PADDOCK

NELSON

SHAFTER LAKE

DEEP ROCK

Andrews

DRINKARD

MARTIN

HARRISON

TEAGUE

ANDREWS

PARKER

CENTRAL

BLOCK 12

W. ANDREWS

FUHRMAN-MASCHO

MABEE

FOWLER

LANGLIE MATTIX

CLABBERHILL

DOLLARHIDE

BEDFORD

THREE BAR

N. HOLT

E. EMMA

MIDLAND FARM

Stanton

JUSTICE

EMBAR

EMMA

HOLT

DUBLIN

N. GOLDSMITH

RHODES

SOUTHEAST NEW MEXICO *Oil and*

HALE
PETERSBURG
ARICK
FLOYD
ANTON-IRISH
LUTRICK
CRAVENS
SMYER
Levelland
Lubbock
LEE HARRISON
STINNETT
LUBBOCK
Crosbyton
CROSBY
ROPES
MOUND LAKE
Brownfield
LYNN
Tahoka
P.H.D.
GARZA
Post
GARZA
O'DONNELL
JUSTICEBURG
CORRIGAN
WELCH
N. GAIL
WINFIELD
DERMOTT
N. SNYDER
BORDEN
BORDEN
SNYDER
DAWSON
Lamesa
Gail
SPRABERRY
S. GAIL
DIAMOND "M"
SCHATTE
SHARON RIDGE
VON ROEDER
GOOD
N.W. VEALMOOR
REINECKE
VEALMOOR
E. VEALMOOR
GARTNER
VINCENT
DUNN
COLEMAN RANCH
WESTBROOK
MARTIN
HOWARD
IATAN-EAST HOWARD
DOCKERY
Big Spring
MORTIA
MOORE
SNYDER
Stanton
HOWARD-GLASSCOCK

Gas Fields

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MOTLEY

COTTLE

"JY"

Dickens

DICKENS

Guthrie

BATEMAN RANCH

KING

ROSS RANCH

CARLISLE

KENT

STONEWALL

BOYD

SALT CREEK

Clairemont

CLAIREMONT

Aspermont

SPIRES

POLAR

ASPERMONT

COGDELL

PARDUE

HOWARD

ROTAN

ROUND TOP

ROYSTON

JONES

STEPHENS

EARLY

BENNETT

B-B

MCCAULLEY W.

NEINDA

ANDERSON

SCURRY

Roby

FARNSWORTH

FISHER

Snyder

MINTER

BARTLETT

KELLY

HERMLEIGH

ROBY

FRAGOSA

NOODLE CR.

STANLEY

NOODLE CR.

CADE

ESKOTA

PITZER

S. NOODLE CR.

LARGENT

TRENT

FAVER

Sweetwater

MCLEOD

PATTERSON

SWEETWATER

GIBSON

BIRD

REIDENBACH

MURPHREE

INGRAM

Colorado City

ROSCOE

NOLAN

TAYLOR

EASTERN PLATFORM

BLACK RIVER

NEW MEXICO

TEXAS

MASON

TUNSTILL

LOVING

CHAPMAN

DELAWARE BASIN

WHEAT

DIXIELAND

Mentone

RUSTLER HILLS

CULBERSON

ANTHONY

Pecos

REEVES

COOPER JAL

HARRIS

TEAG

FO

LANGLIE MATTIX

JU

DUB

RHOD

EAVES

SCA

LECK

HENDERSON

HENDRICK

MAGNOLIA SEALY

MONROE

S. MAGNOLIA SEAL

LION

QUITO

PYOTE

WARD

SPEN

SCOTT

VERHALEN

RICHARDS

CHANCELLOR

OATES

JEFF DAVIS

BREWSTER

LEGEND

OIL GAS

CRETACEOUS PRODUCTION

PERMIAN PRODUCTION

PENNSYLVANIAN PRODUCTION

MISSISSIPPIAN PRODUCTION

DEVONIAN-SILURIAN PRODUCTION

ORDOVICIAN PRODUCTION

0 5 10 20 30 MILES

Andrews
ANDREWS
PARKER
MARTIN
BLOCK 12
W. ANDREWS
FUHRMAN-MASCHO
MABEE
FOWLER
JUSTICE
DOLLARHIDE
BEDFORD
THREE BAR
EMBAR
CLABBERHILL
N. HOLT
E. EMMA
EMMA
HOLT
MIDLAND FARM
Stanton
DUBLIN
HODES
N. GOLDSMITH
GOLDSMITH
N. COWDEN
SCARBOROUGH
FLYING "W"
KEYSTONE
TXL
JOHNSON
LAWSON-SIMPSON
FASKEN
Midland
WARFIELD
S. MIDLAND
TEX-HARVEY
MIDLAND
Kermit
KERMIT
WHEELER
ECTOR
FOSTER
Odessa
WINKLER
TXL
HARPER
ADDIS
S. COWDEN
WEINER
MOSS
EMPEROR
N. MONAHANS
HALLEY
LOWE
YARBOROUGH & ALLEN
PENWELL
DOURO
JORDAN
SWEETIE PECK
PEGASUS
EDWARDS
MONAHANS
Monahans
WADDELL
C-BAR
N. WARD
S. MONAHANS
ELLA WADDELL
UNIVERSITY WADDELL
DUNE
SEALY
ESTES
SPENCER
SAND HILLS
PEMBROOK
W. SAND HILLS
BLOCK 31
WILSHIRE
UPTON
BYRD
S. WARD
SHIPLEY
S. SAND HILLS
CRANE
Crane
MCELROY
NEAL RANCH
DOBBS
NICHOLS
TUCKER
SOUTH CRANE
BENEDUM
HUMBLE-TUCKER
NETTERVILLE
PAYTON
MCKEE
CORDONA LAKE
OWENS
T.C.I.
ORIENT
MALICKY
ABELL
CRANE COWDEN
SANTA ROSA
GRASSROOTS
LEHN-APCO, N.
HERRINGTON
Rankin
JAMISON-POLLARD
PECOS VALLEY
N. HEINER
LEHN-APCO
MCCAMEY
HURDLE
SHEARER
E. APCO
MASTERSON
CROSSETT
GRAYS
HEINER
IOWA
FROMME
WEBB-RAY
CRESSE
APCO WARNER
CROCKETT
OWEGO
WENTZ
TIPPETT
FORT STOCKTON
MAC DER
MULE CREEK
TOBORG
WALKER
CHARLES
Fort Stockton
MCKENZIE
WHITE & BAKER
YATES
NOELKE
WESTERMAN
PECOS
OLSON
CLARA COUCH
LA GLORIA
COX

ENTRAL BASIN PLATFORM

MARTIN

HOWARD

IATAN-
EAST HOWARD

DOCKERY

MITCHEL

Big Spring

MORTIA

SNYDER

MOORE

Stanton

HOWARD-GLASSCOCK

SPADE

IOLANTHE

FASKEN

Midland

MIDLAND

GLASSCOCK

WARFIELD

S. MIDLAND

TEX-HARVEY

MIDLAND

GARDEN CITY

STERLING

Garden City

Sterling

DURHAM

MARVIN

WEETIE PECK

PEGASUS

CLAR

BASIN

PEMBROOK

WILSHIRE

UPTON

NEAL RANCH

BENEDUM

Stiles

REAGAN

IRION

HERRINGTON

Rankin

BIG LAKE

TANKE

BARNHART

HURDLE

GRAYSON

NE WORLD

WEBB-RAY

CROCKETT

MOORE

NEAL

BLOCK 47

TIPPETT

WORLD

TOBORG

UNIVERSITY BLOCK 39

CHARLES

MIDWAY LANE

YATES

CROCKETT

CHILDRESS

NOELKE

SHANNON

TODD

VAUGHAN

OLSON

W. TODD

WYATT

SIMPSON

BEAN

PIKE'S PEAK

CLARA
COUCH

HOOVER

COX

LANCASTER HILL

Ozona

CHELL

NOLAN

TAYLOR

PLATFORM

JAMESON

ARLEDGE

BLACKWELL

SAN BENITO

W. FORT CHADBOURNE

FORT CHADBOURNE

LLOYD

LYGAY

N. WINTERS

COKE

MILLICAN

Robert Lee

BRONTE

SELLS-MITCHELL

S. BRONTE

rling City

WENDLAND

RUNNELS

TENNYSON

RVIN

CLARK

WATER VALLEY

NORTH MILES

FUNK

PULLIAM

San Angelo

TOM GREEN

CONCHO

Sherwood

MERTZON

IRION

SUSAN PEAK

ANKERSLEY

S. SUSAN PEAK

OLIVER

SCHLEICHER

MENARD

BAUGH

MORROW

ELDORADO

Eldorado

PAGE